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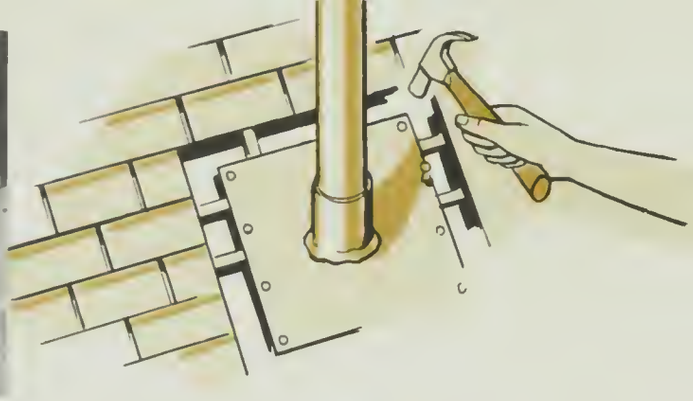
15

ROOFS

SCIENCE PROJECTS

do-it-yourself

Complete Handyman do-it-yourself Encyclopedia



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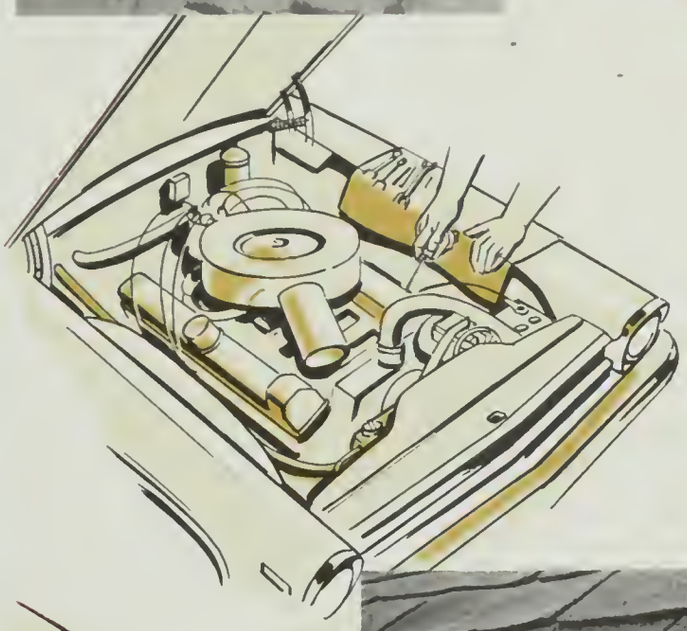

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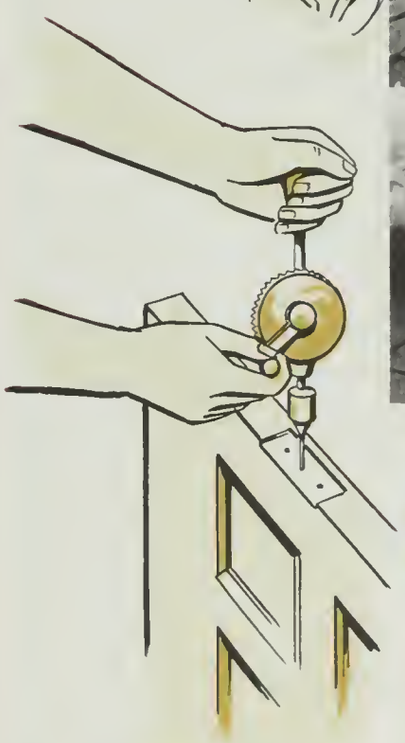

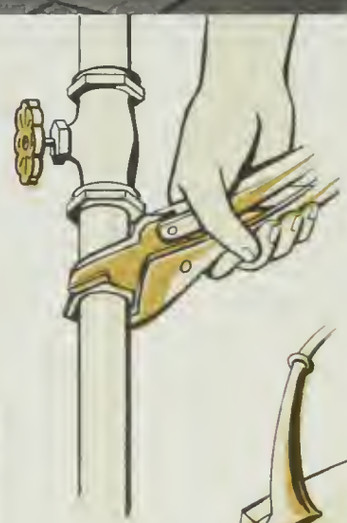

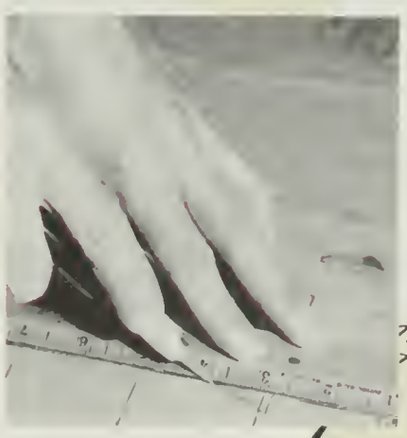

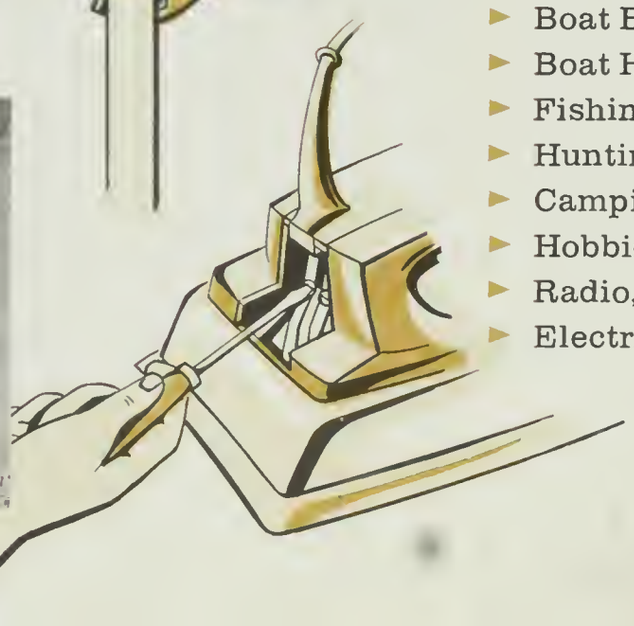

Complete Handyman yourself Encyclopedia

A COMPILATION OF NEW AND PREVIOUSLY PUBLISHED SPECIAL INTEREST PROJECTS AND MANUALS FOR THE REPAIR AND CARE OF HOMES, AUTO, APPLIANCES, HOBBY EQUIPMENT.

by the editors of

Science & Mechanics

15

ROOFS

SCIENCE PROJECTS

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VOLUME 15

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Enlarge Your Home by Raising the Roof

This method of increasing the size of your house involves some extra effort—like dismantling the old roof—but it can add substantial living space without using one additional square inch of land

If your not-so-old homestead is beginning to feel a bit bulged by the family and its space needs, it might be a good idea to raise the roof of your otherwise peaceful abode.

The home illustrated was a typical postwar ranch house with three bedrooms, living room, kitchen, utility room, and bath shoe-horned into 1000 square feet of space on a lot adequate only for the existing house and outdoor living requirements.

Problems were typical, too. Three bedrooms were simply not sufficient for a growing family. Moreover, one of the bedrooms was only 11 feet 8 inches x 8 feet 6 inches and it lacked a closet. The living area, 17 feet x 11 feet 8 inches was too modest-sized for comfortable entertaining of guests.

Because the house had no basement, an extra large utility room was required, putting a space squeeze on livable area. Even so, the accumulation of possessions that mark a family with children going into teenage independence made storage inadequate, particularly for clothing.

Finally, the family was fighting the common battle of the morning bottleneck at the bathroom door. One bath was not sufficient.

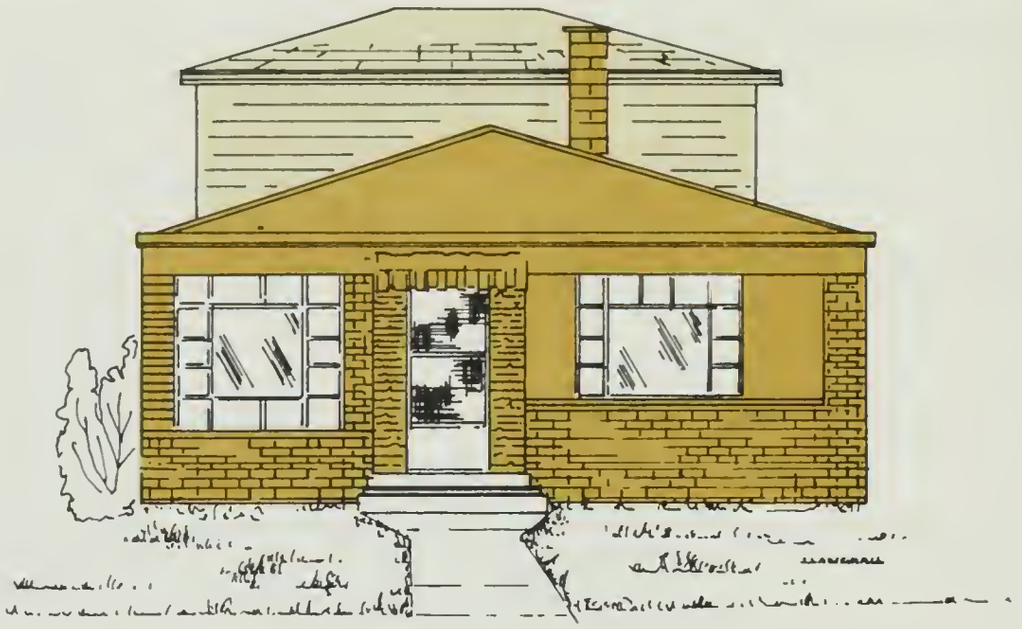
The owner faced three alternatives: (1) sell and move, an unappealing possible solution because both parents and children had sunk their roots deep in the community; (2) build outward with a room or wing addition—also an unacceptable solution because it would use up too much of an already small back yard; and (3) build upward by placing a second story atop the existing one.

Alternative number 3 was selected, although it presented problems of its own. The two main ones were the trouble and expense of taking down the roof structure to rebuild it one story higher, and living inconveniences while the addition was being built overhead.

Still, this alternative would keep the family in its established location. Backyard cookouts and other activities would not suffer from reduction of outdoor space. By careful planning both major problems were satisfactorily solved.

With some free professional guidance

rooftop antenna: see antenna
room addition: see home improvement



Street profile of brick veneered hip roof ranch house typical of many small postwar homes. A new partial second story with two bedrooms and bath was added by owner.

from a materials supplier, the owners designed a second-story addition just large enough to provide what they envisioned were their specific space needs.

This included two extra bedrooms with ample closets, a second bath, and a stairway to the addition. Thus expense was limited to building an addition of 18x25 feet. With the owner doing the major part of the work and reusing some roof framing materials, even greater saving was achieved.

The second major problem, that of disrupting the household while work was in progress, was kept to a minimum by scheduling steps in proper sequence. The existing superstructure was removed and the addition was framed and roofed over as quickly as possible. One large window was left as a rough opening so that material could be brought in through it instead of through the house. And building of the stairway was delayed until last.

In this way, the downstairs was virtually undisturbed during most of the project. Existing paint, finish, and furniture were spared the chips and the knocks bound to occur when building materials are carried through living quarters.

In adding two bedrooms upstairs, it was possible to lengthen the living area to 22 feet by removing the wall that formerly separated it from the smallest bedroom. The stairway to the new bedrooms was built in a corner of the enlarged living room.

Plumbing for the new bathroom was simplified by locating this room directly above the existing bath, thus saving time and material. Heat runs were extended from the existing forced warm air furnace to the new addition. And while they were at it, the owners increased electrical service capacity from 60 to 100 amperes.

Put your plans on paper. If raising the roof in a like fashion can solve similar problems for you, your planning should include careful and detailed study to assure that the addition meets the needs without expensively exceeding them.

Conversion can be done in stages. In this example, the second story was added to

only the rear 18 feet of the house. However, the stairway is located so that any time in the future the second story can be extended over the entire structure.

After taking careful measurements of existing floor space and considering various room arrangements for the second floor addition, put your ideas in sketch form. Floor plans and elevation views can be drawn most easily on paper that is cross-ruled in ¼-inch squares. Each square can represent a square foot of space.

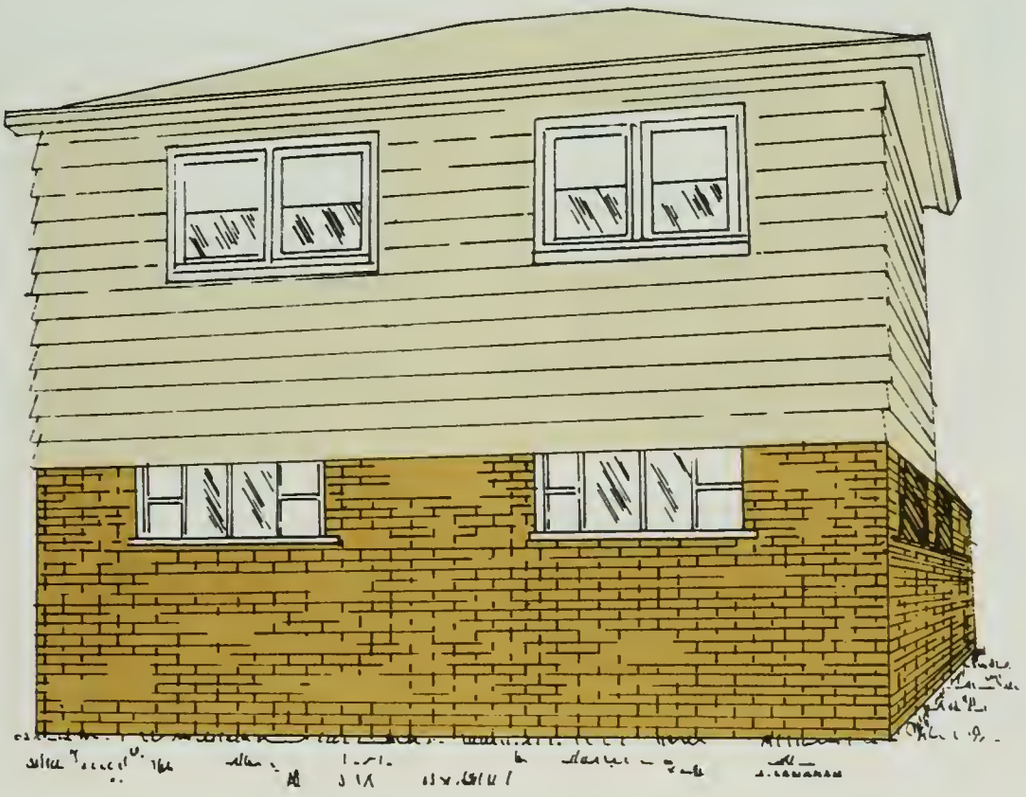
Draw in location of the chimney, soil stack vent pipes, outer walls, of course, and interior load-bearing partitions. Then add the exact position of the proposed stairway, any relocated partitions on the first floor, and partitions, windows, and doors upstairs. The plan should show the proposed position of bathroom fixtures, beds, switches, convenience outlets, lights, and heating outlets.

Best appearance is achieved by sizing windows in the addition to conform to those below, and locating the new windows directly above the existing ones. Greatest economy is made possible by building load-bearing partitions above those walls which presently carry the roof weight.

When your plans are all on paper, you can save time and perhaps prevent an error or two by getting an experienced, structural draftsman to prepare detailed working plans. When getting competitive costs estimates, try to base them on the same materials, quality, grade, and size. If you intend to do the work yourself, your lumber dealer will help you figure the materials needed.

Check ceiling joists. Before any work is started on the addition, existing ceiling joists should be checked because wider joists will alter head-room dimensions, if

From the rear, the enlarged home looks like a two story structure, with windows above closely matching windows below. Aluminum siding was brought down to extend over trim board above original brick veneer.



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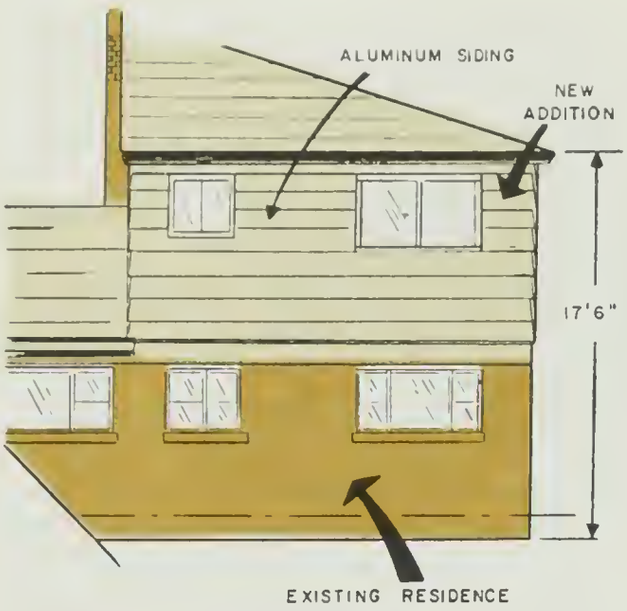
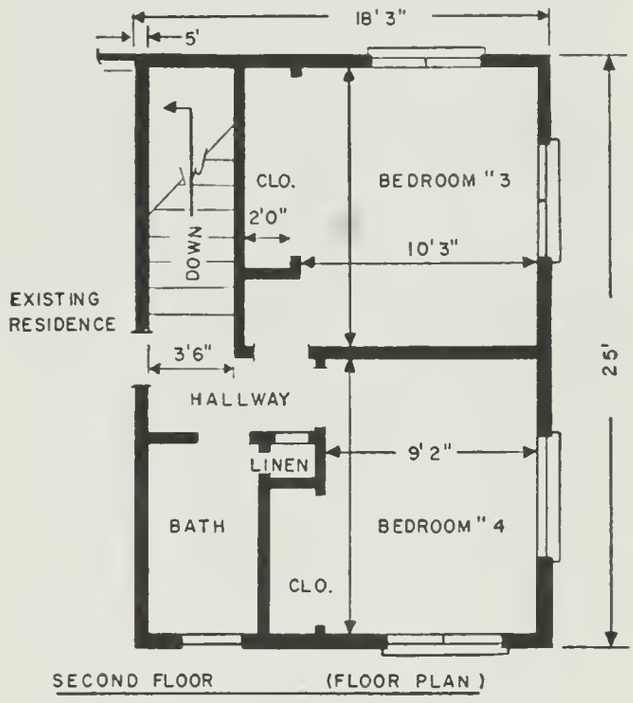


(RIGHT SIDE ELEVATION)



SECOND FLOOR (FLOOR PLAN)

they are to be installed. Where conversion was not anticipated at the time of building, only 2x6 ceiling joists may have been used. When spaced at the customary 16-inch centers, joists of this size should not have a span longer than 7 feet, if they are to carry a minimum floor load of 40 pounds per square foot with safety.

Enlarge Your Home by Raising the Roof

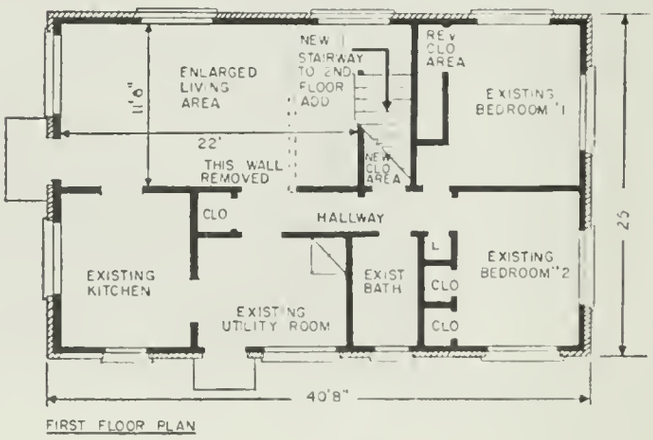
Depending on span, 2x8 or 2x10 joists will take the load of added rooms. Sometimes existing ceiling joists can be strengthened sufficiently by doubling their thickness with new joists of the same size nailed to the old. However, in most cases where the joist structure must be strengthened, wider joists are installed. These may be placed alongside existing joists and nailed to them, or separated from them.

To install extra joists between existing ones, it will be necessary to remove bridging. New block bridging is installed later, except in cases where joists are intentionally separated to minimize noise transmission. To raise joists above keyed plaster, they can be set on blocks of uniform thickness, nailed either to the plates or to the joists. The ends of joists usually must be cut off at an angle to clear the roof sheathing.

Joists that support a bathroom floor should be capable of holding a load of 60 to 70 pounds per square foot because of the added weight of plumbing fixtures, and perhaps also a ceramic tile floor.

Dismantling the old roof. After plans for the addition are crystallized, the second step is to tear down in preparation to rebuild. This is easiest when done by two men above and a helper below to stack those materials that can be reused. Tear down in reverse order from the sequence under which the house was built.

A portable scaffold is used, or you can



FIRST FLOOR PLAN

build your own of 2x4 uprights which may be later used for framing partitions—after the exterior is completed. Walk planks may be borrowed or purchased as cull material from a lumber yard.

There may be slight variations according to the construction of your house, but here is the ordinary sequence of removal. You'll need a nail puller, both a thin, flat chisel and cold chisel, crowbars, hammers, and possibly a hacksaw.

Starting from the bottom, remove downspouts, then gutters, fascia board, and other attachments like television antenna and ground wire. With the fascia off, you can get at the soffit to pry it off.

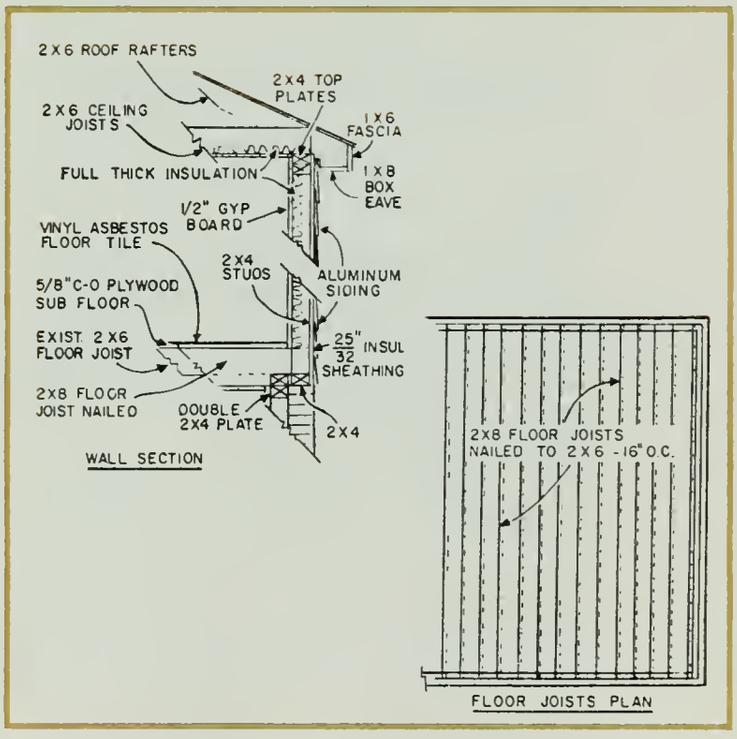
Next, shingles should be removed. If you are doing the work yourself and time cost is not a factor, nails can be pried out carefully to preserve good shingles for reuse.

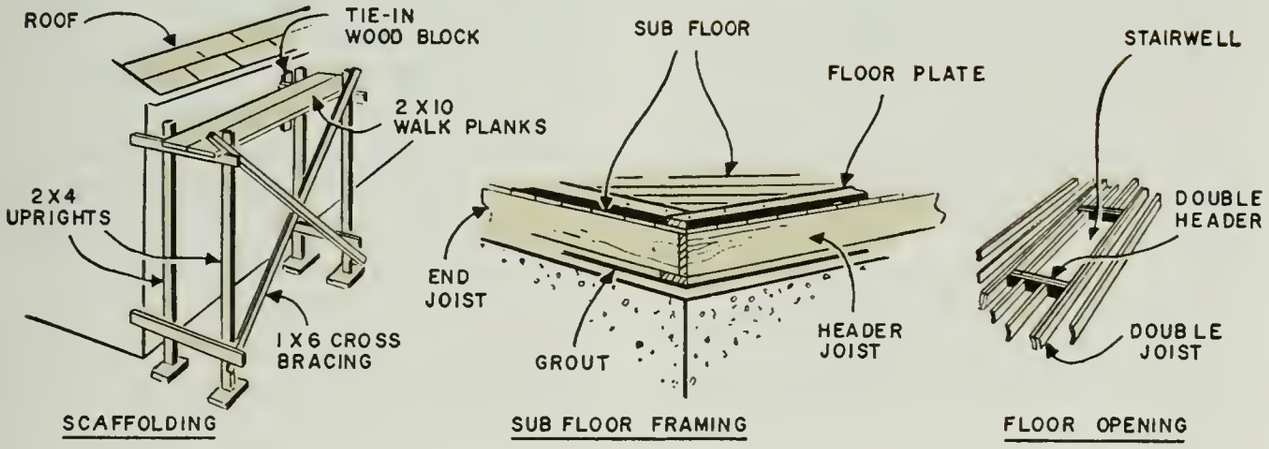
Next, and probably the toughest job, is to remove the roof sheathing. With the framing thus opened up, collar beams, rafters, and any knee-wall studs are easily pried loose to be stored for reuse.

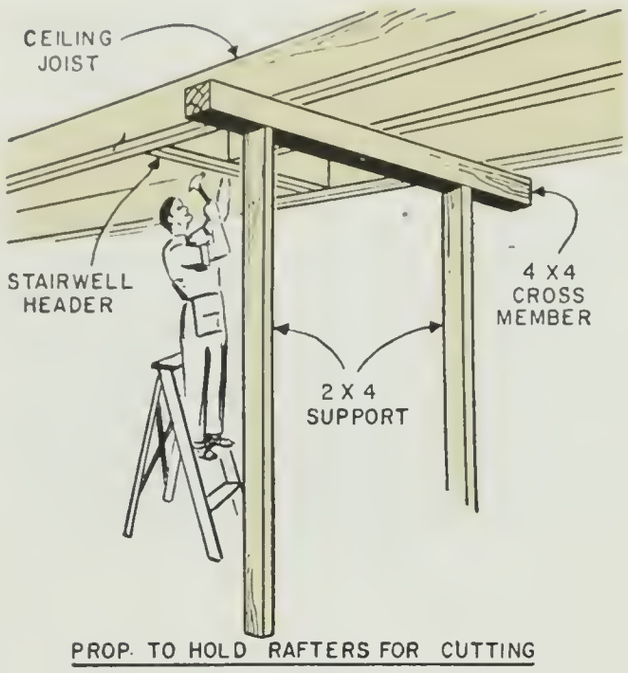
If gable end studs are extensions of the wall studs for the first story, mark and saw these at the same height, if possible, as the sidewall studs. Thus you can build a new subfloor platform for the second story that is similar to that used as a deck for a modern home's first floor.

In the example illustrated, the existing house was brick sided, and this provided a slightly different reframing situation than for the more common non-masonry wall.

With the roof stripped off, you'll be in a hurry to extend the framing and get the new structure under weather protection. In areas of frequent rain, or during periods when snow is likely, it is wise to plan on covering the work for protection—particularly if you are doing the work with little help. If you can't borrow or rent enough large tarpaulins for covering, a good alternative is to buy sheets of polyethylene film, as wide as you can get them, and improvise an easily erected and dismounted







PROP TO HOLD RAFTERS FOR CUTTING

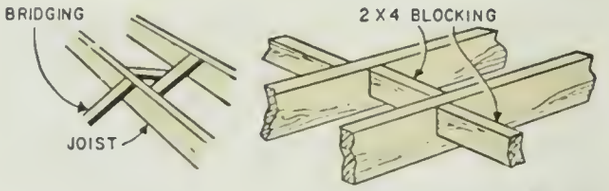
tentlike frame to provide a water runoff slope.

Framing the new structure. The third step—framing the new structure—is started by building the floor pattern. As mentioned previously, it is unlikely the existing ceiling joists will be strong enough for a new role as floor joists.

In building the platform, extend the joists within 1⅝-inch of the outer edge of existing framing, and install a header using 20*d* nails. It's easiest for a do-it-yourself to use joists that extend from one side of the house to the other, and this is possible if the width of the house is not more than 26 feet.

Stairwell opening and any other opening between floors must be framed out with additional supports. It will probably be easier for you, unless you've had considerable experience, to install all joists first and then go back to cut out the openings. The reason is that locations of existing ceiling joists determine where you place the additional, stronger floor framing members.

Prop up the joists to be cut from underneath. Then mark your opening across the joists and on the underside of the ceiling.



BRIDGING BLOCKING FOR PLYWOOD SUBFLOOR

It's best to saw the ceiling material from below, and the joists from above.

The cut ends of the joists should be supported by double headers of the same stock as the joists. If there is no regular joist on one side of the opening due to manner of spacing, install a double trimmer joist at that position. Trimmer joists should not be doubled until after the header joist has been put in place and nailed to the single trimmers. The reason is that your 20*d* nails are not long enough to give the header adequate support.

Bridging should be installed for every 8 feet of joists. These may be 1x3s cut with a bevel at each end, or may be metal bridging pieces obtained at your dealer.

Laying the subfloor. After floor framing is completed, the subfloor is laid. It can be of subfloor grade plywood, or of either straight-edged or tongue and groove lumber.

Unsanded structural grade interior type fir plywood, ⅝-inch thick, makes for a strong, even, and quickly installed subfloor. Lay the 4-foot wide panels so that the face grain is at right angles to the joists. Fasten the plywood with 8*d* nails on about 6-inch spacing along the edges, and 12-inch spacing in the panel's field.

Edges of the plywood should center on joists wherever possible, or on either block bridging or 2x4 stock installed between the joists. Stagger blocking slightly so they may be end nailed through the joists. Provide blocking for plywood edges between joists.

Tongue and groove stock may be end-matched so that joining edges will lock together—and the boards need not be sawed off to center on joists.

A subfloor of 1 inch, end-matched, tongue and grooved stock should be nailed with two 8*d* nails for a board width up to 6 inches, and three nails for width over that. Such subfloor should be laid diagonally for greatest strength, and to lay finish floor either way.

Subfloor boards should be squeezed together as tightly as possible if green, or in humid weather when they may have expanded. Under dry conditions, they should be assembled loosely to prevent buckling with more humid weather.

Whatever material you use, take the small bit of extra time necessary to use spiral or ring-groove nails—which do not loosen like ordinary nails and will help keep your floor from squeaking

Framing exterior walls. When the subfloor is in place, the next piece of work is framing of exterior walls. For this, obtain precut 2x4 studs if possible and feasible. Using these saves a considerable amount of time and assures you of greater precision than hand-cutting.

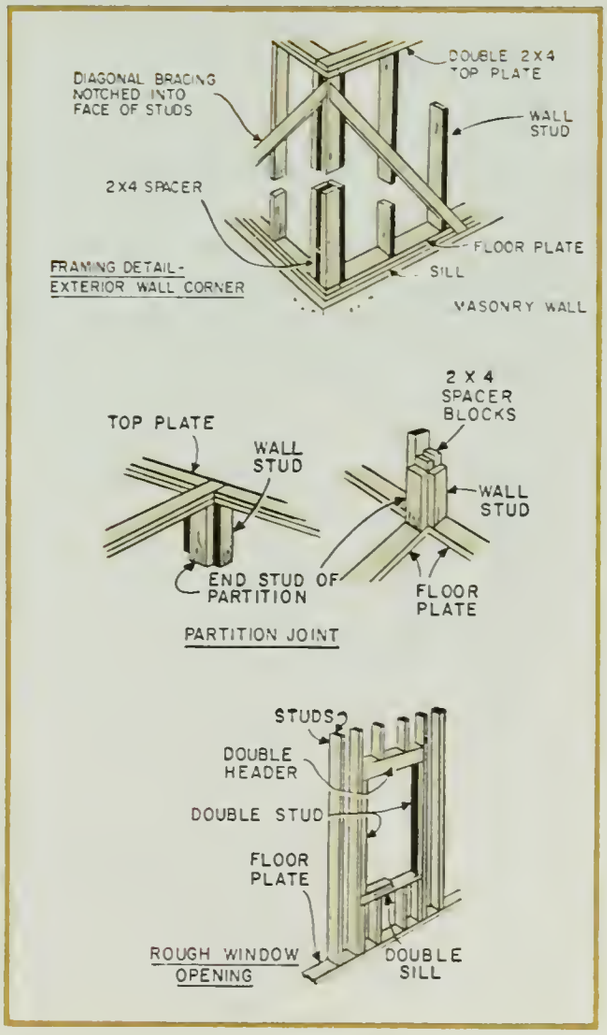
There are several methods you can use in framing the walls, but the fastest and best is to pre-frame sections directly on the subfloor. When put together, the sections can be hoisted into place and braced for securing to the joists, through the subfloor, and to each other.

Studs should be spaced 16 inches on center and endnailed with two 16*d* nails through the sole and top plates. Separate pieces of 2x4 plate should be joined at the center of a stud.

In framing, make a corner post at the end of each side wall by spacing two studs with pieces of 2x4. When walls are up, this provides a nailing base for interior wall finishing material on each wall.

If desired, you can make stud spacing adjustments to provide an exterior wall stud in correct position for joining each partition. In this way, only one stud needs to be added when the partition is actually erected. Most do-it-yourselfers find it doesn't pay to try saving a stud, and will put the two-nailer studs in position wherever called for at the time the partition is built.

Window openings should also be framed in as the wall is built on the subfloor. Locate the window and nail two studs into position, each 1⅝ inches outside the mark for rough opening as called for in the specifications accompanying the window you'll be installing. Then cut the double header pieces to fit between these studs. Space the two pieces of the header with short pieces of ⅜-inch lath, and nail them together with 16*d* or 20*d* nails. Use 2x4 headers for rough openings up to 3 feet 6 inches, 2x6s for openings up to 5 feet, and deeper headers for wider openings according to the rec-



ommendations of a dealer, architect, or engineer.

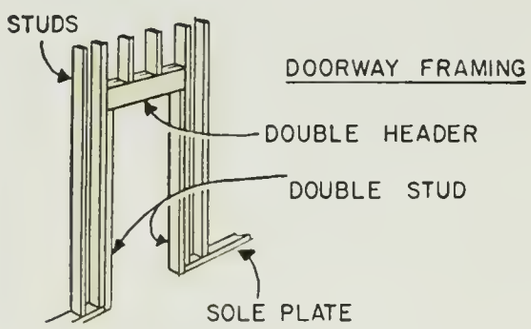
Locate the bottom edge of the header at the rough opening mark and nail in place. Then install cripple studs.

When wall sections are framed, erect them and temporarily brace them in place. Plumb and nail each section to the joists and header, through the subfloor.

Interior partitions. After the exterior walls are up, frame and erect interior partitions in the same manner, making door openings. Then tie the walls and partitions together with the upper 2x4 of your top plate.

If non-structural fiberboard, insulating, or horizontally-applied sheathing is to be used, shiplap diagonal corner bracing should be let into the studs with a saw and chisel. Structural grade insulating sheathing, plywood, or diagonally-applied board sheathing does not require such corner bracing.

Framing the roof. After the wall is sheathed, you're ready to frame the roof. There are several different roof profiles from which to choose. Most common are the simple gable and the hip roof. The house in this example had a hip roof and the same profile was carried through on the addition by reusing all the old rafters possible.



First step in framing the superstructure is installation of ceiling joists spaced at 16-inch centers. Because these will not carry weight, they can be more shallow than floor joists. Use 2x4s for spans up to 10 feet, 2x6s up to 14 feet, and 2x8s will span any likely width above that. Toenail ceiling joists into the top plate with two 10*d* nails on each side.

Rafter installation will be simple if you have retained dimensions and plan to reuse the old members. Install them in the same manner by which you took them off.

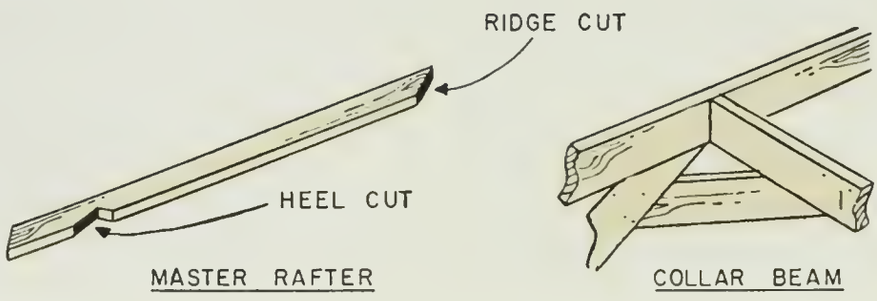
If rafters cannot be reused, you'll need to cut a master rafter carefully to be used as a pattern for the remainder. If you're unfamiliar with use of the framing square, this first rafter will have to be marked by holding it in place, allowing for width of the ridge board.

End rafters should be installed first, flush with the outer edge of the top plate. Install rafters a pair at a time, nailing to the ridge board and toenailing to the plate as you go along, or a metal rafter tie may be used.

The heel (lower) cut of the rafter should sit for its entire surface on the top plate. Rafters are spaced 16 inches on center. If there is a crown in any member, it should face up.

To tie the rafters together, nail collar beams across them about a foot or two down from the ridge board. Use 1x6s for this purpose and cut off their upper corners flush with the rafters.

Next, frame the gable ends with studs



notched to receive the rafters. Toenail these studs to the top plate directly above the wall studs.

Roof sheathing may be ⅜-inch exterior type fir plywood—preferable because of its lay down speed, or shiplap. If you were careful in removing the old decking, you may have practically enough material for covering.

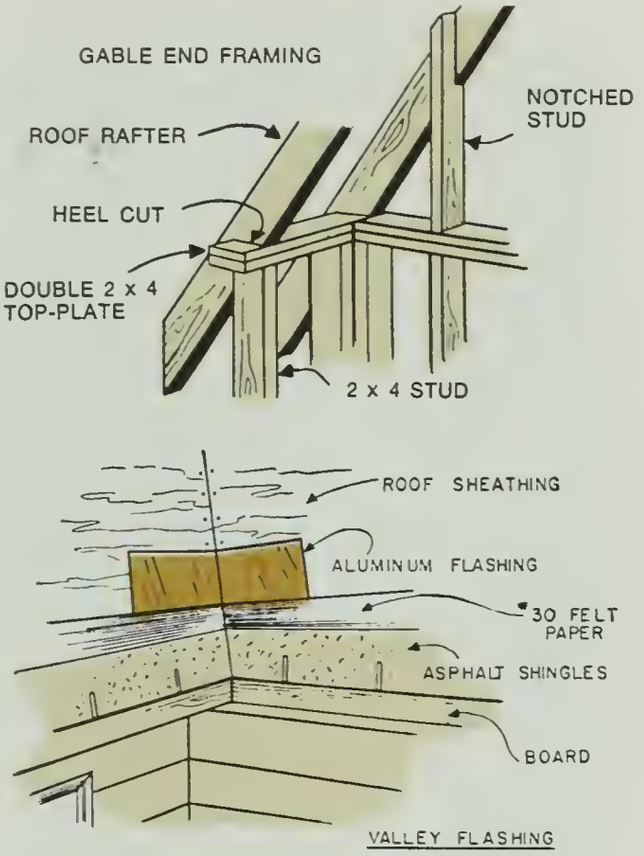
Nail plywood decking in the same manner as that described for the subfloor deck. If boards are used, they should be staggered so that the ends of no more than two to four of them fall on the same rafter. Nail these with two 8*d* nails to each rafter.

Flashing the roof. Before shingling, flashing should be installed. Strips of non-rusting sheet metal, like aluminum, are used in 18-inch width at valleys. The juncture between the new wall and existing roof should be similarly flashed.

Flashing strips that join a roof to a wall horizontally go behind the lowest course of wall covering such as siding and are extended a few inches over the top shingle course of the adjoining roof. Where the roof slopes along a wall to which it is joined, use short strips for flashing, extending each over the one below it and under the adjoining roof shingle.

Shingling the roof. The roof may be shingled with the material saved—if there is enough of it in good condition, or if the color can be matched. Otherwise, you may choose material coated asphalt shingles, wood shingles, asphalt cement, tile, metal, or roll roofing. For roof slopes of less than 3 inches to the foot, apply built up roofing —succesive layers of either tar and tar-impregnated paper topped with gravel, or asphalt and asphalt-impregnated paper.

Before laying asphalt shingle strips, cover roof sheathing with building paper applied horizontally. Each strip should overlap the one below it. Nail a starter strip of roll roofing along the lower edge of a roof to project about ⅜-inch at both bottom and sides. A row of shingles, applied in reverse position, may be substituted for the starter strip.



The first row of shingles is applied directly over the starter strip. A pair of nails (1-inch heavily galvanized or aluminum roofing nails for asphalt shingles) are driven just above and to each side of every shingle slot.

Wall coverings. You have a choice of many kinds of exterior wall coverings—wood planking, siding, shingles, exterior-type plywood, wallboard, stucco, brick, stone, and imitation stone. Siding used in the house illustrated was aluminum, installed similarly to wood siding.

Installation is started at the bottom of a wall. Each piece overlaps the upper edge of the previous one. Overlap varies with the width of the siding. Butt siding up tightly against door and window frames and against corner boards previously installed. Joints of siding should be centered over studs, those of alternate courses staggered.

At windows, siding should line up with the top of the door and window drip caps, and with the lower edges of sills. Aluminum nails, which do not rust and cause streaks, make frequent repainting unnecessary. Aluminum siding also is available and should always be applied only with aluminum nails. Non-rusting flashing is placed over drip caps of doors and windows.

Plywood and wallboard for exterior use can be obtained in the form of large sheets 4 feet wide, or in the form of wide siding (usually 12-, 16-, and 24-inch widths). The latter may be simply overlapped like regular siding, or the overlap may be accentuated with "shadow strips" placed between overlapping edges.

Building the stairway. After the exterior is completed, the next step is building a stairway to the addition. There are three basic types—a straight flight, L-shaped, and U-shaped.

The example here required an L-shape rise. The owner moved back the wall to extend the living room, and built the stairs exposed to the living room.

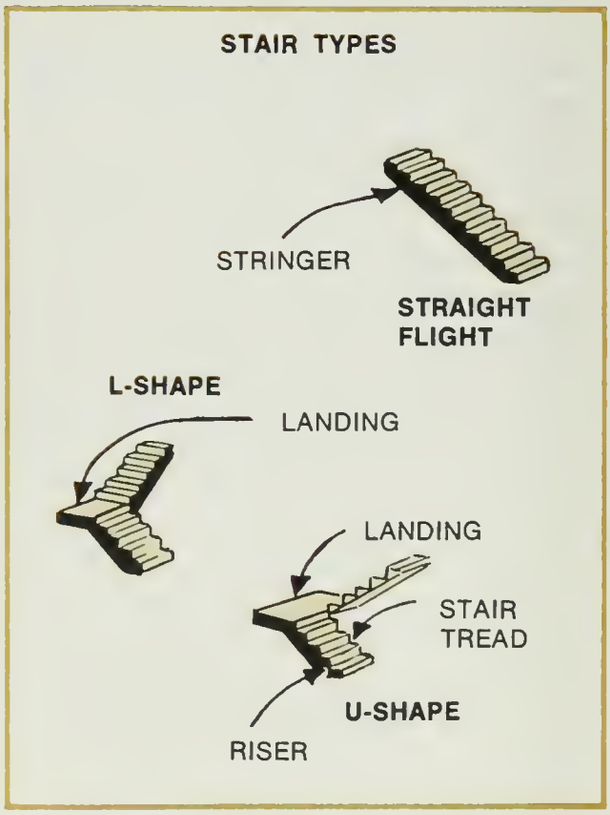
The first step in building such a stairway is to make the landing at the bottom, which constitutes the first step. The base of the landing is made from two pieces 2 x 8¼-inch, extending 9¾ inches beyond the inside edge of the 2x4 framing for the partition wall. This will provide a tread 9 inches wide. Next, cut a piece of 1x12 to fasten to the wall above the first 2 x 8¼-inch pieces. Another 1x12 should be installed against the wall behind each stair stringer.

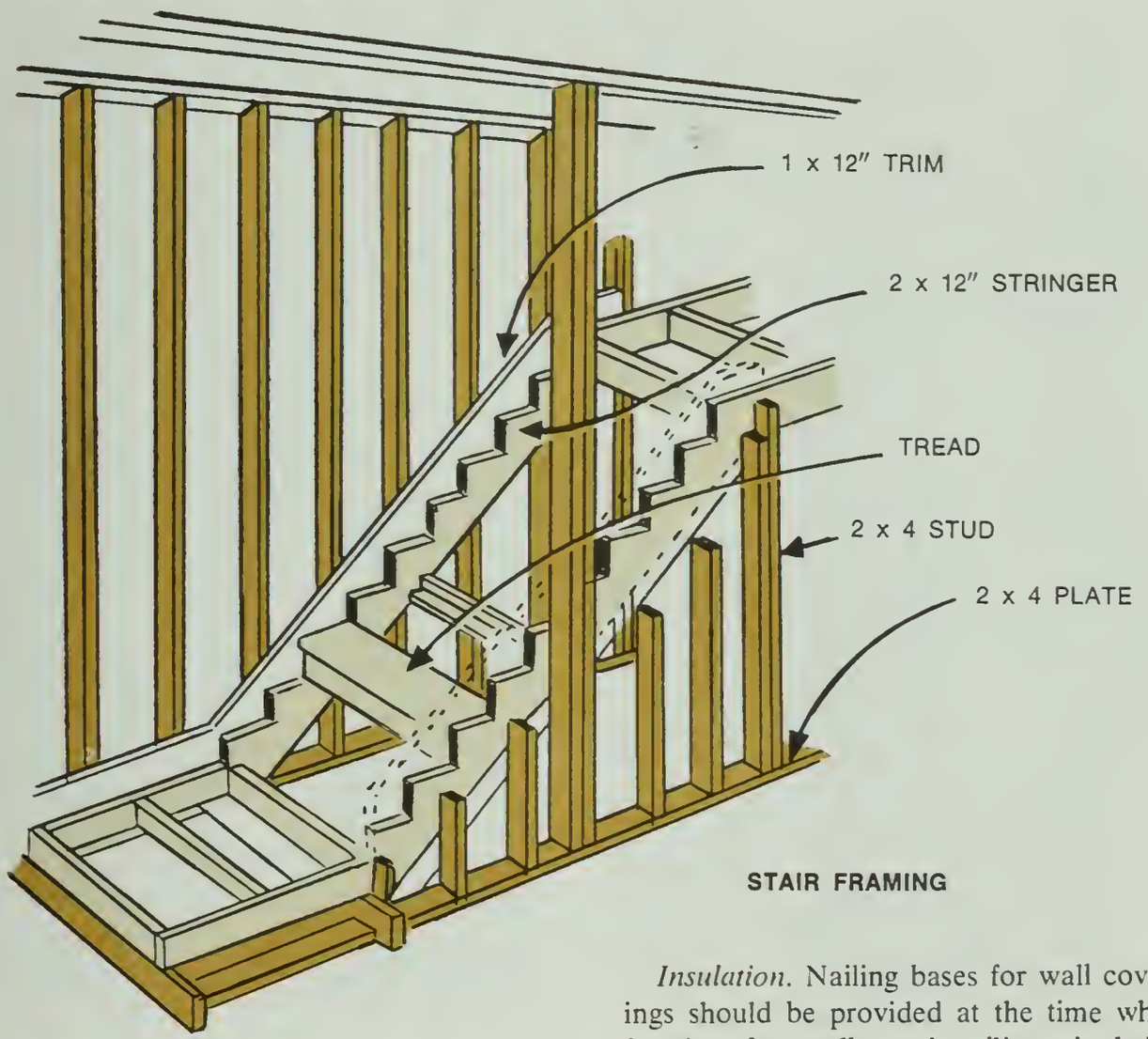
Next, box in a second step, which makes the landing, of four 2 x 8¼-inch pieces. Set the front pieces even with the inside of the 2x4 partition. Then cut 2x12 stringers with a notch to fit over the edge of the landing frame, making a rise of 8¼ inches for the first step beyond the landing. At the top, cut the stringers to fit snugly under the bottom edge of the ceiling joists.

Use a steel framing square to mark out the sawtooth pattern for 8¼-inch risers and 9¾-inch tread bases. Make sure that both stringers are marked the same, then cut. Before permanently fastening the stringers in place, erect the bracing as shown. Treads and risers can be purchased from standard stock to fit stringers with these dimensions. They should be nailed with casing nails countersunk into the wood.

Wiring, plumbing, and heating. All underfloor wiring, as well as underfloor plumbing and heating extensions, should be finished before the subfloor is laid. Electric cables can be left long enough to be threaded through sole plates of partitions later. After the framework of partitions and ceiling is in place, the rest of the concealed work can be finished. Wiring of rooms should not be added to any existing branch circuits, but should be set up as independent circuits.

Water supply and drainage pipes for a new bathroom generally are extensions of the existing plumbing system. Copper tubing for water supply as well as hot water





STAIR FRAMING

heating can be installed in partitions easily, and connected to standard pipe with adaptors. Water supply pipes should not be installed in outside walls in localities where the temperature drops below freezing during winter months, unless the pipes are protected with insulation.

To take care of the added heating requirements from an existing system, it may be necessary to increase the size of a hot water boiler, insert a circulating pump, or replace an old gravity type warm-air furnace with one having forced circulation. Or, the new rooms can be served by individual gas or electric heating units recessed in walls or installed in ceilings. In this particular case, extra heat runs were extended to the bedroom addition.

Insulation. Nailing bases for wall coverings should be provided at the time when framing for walls and ceilings is being erected, and before any insulation is applied. Such bases are provided by sole and top plates of partitions, by the framing of doors and windows, by double studs arranged at right angles to each other at corners, and by filler blocks of 1-inch stock nailed to the framing where necessary.

Where two wide panels of wallboard are to be placed horizontally, a 1x3 strip can be mortised into the studs at the point where the panels are to meet. Generally, forms of wallboard known as planking and tile will require furring strips nailed across studs or joists and spaced from 8 to 12 inches.

Insulation is installed next. There are three basic types: (1) batt, blanket, or quilt, (2) loose fill, and (3) reflective foil.

Batt or blanket insulation usually has a covering that projects beyond the edges for nailing or stapling. Loose fill insulation is poured between floor and wall joists. Reflective foil insulation is nailed or stapled to the joists with the shiny side away from the worker.

Insulation applied between rafters above a sloping ceiling should permit air to pass between the insulation and the roof sheathing, from the unheated spaces at eaves to the space above the attic rooms.

Insulation and vapor barriers generally are installed at the same time, as most types of batt or blanket insulation have vapor barrier coverings. To be most effective, the barrier should be sealed around pipes passing through a wall, and around electrical outlet boxes.

In the case of loose fill insulation, a separate vapor-barrier membrane is required. It should be brought up along the sides of joists and fastened to them with wood strips. Two coats of rubber base paint will serve almost as well as a vapor barrier.

Finishing. Apply finishing materials first on ceilings and then on walls. Dry wall coverings are easy and economical to install, in a fraction of the time required to plaster walls. Such wallboard includes many types of materials in the form of "building boards" (panels 4 feet wide), planking, and small-size panels, including "tiles." The material may have insulating value, should be tough and rigid, and have great resistance to impact. Some of these coverings come pre-finished in durable, attractive colors, and also are available in various textures.

Fasten wallboard with nails, staples, clips, or with adhesives. Nail and staple spacing vary from 3 to 6 inches along edges, and from 6 to 12 inches elsewhere, as recommended. Some wallboards have beveled edges, which form neat V-grooves when joined. Straight edge joints of wallboards often are filled with a putty or crack-filling compound. Joints, corners, and edges of wallboard may be concealed and protected with special molding of wood or metal. In some instances, these moldings can be obtained in the same material as the wallboard.

Flooring. Besides strip, plank, or block wood flooring, you can have various kinds of composition floors in many patterns and colors or you can use carpeting. Before a finish floor is laid, the subfloor must be smooth and clean so that there are no projecting nail heads or raised edges of boards. Wood flooring is fastened directly to a lumber or plywood subfloor after the subfloor is covered with 16-pound building paper.

For composition flooring, the subfloor should first be covered with an underlayment of ¼-inch tempered hardboard or ⅜-inch fir plywood. Fasten underlayment to the subfloor with barbed, spiral, or ring-groove nails.

Strip flooring of hardwood or softwood comes in various widths and lengths with tongue and groove edges. Lay the first strip with the grooved edge parallel to the wall, and space it from the wall a little less than the thickness of the baseboard. This strip is facenailed near the grooved edge, then blindnailed at an angle, into the base of the tongue. Succeeding strips are blindnailed only. Flooring nails should be 8*d*, preferably ring-groove or spiral, and spaced about 10 inches apart. Plank flooring may be solid wood or plywood. The edges are beveled, and the boards are screwed and nailed to sub-floor.

Wood flooring should be laid in the longest direction rooms. This is possible if the subfloor is plywood, or if a lumber subfloor has been laid diagonally. The flooring of adjacent rooms should run in the same direction, and the joints should be staggered. M.F.

See also: ADDITIONS, HOME; ATTIC; DORMER; GARAGE REMODELING; HOME IMPROVEMENT.

All about Roofing

A roof is not just a lid on the top of your house. Consider appearance when choosing roofing material, as well as cost, durability and suitability for the structure

THE ROOF OVER your head should do more than just keep out the rain, wind, winter cold and summer heat. It should also contribute in a positive way to the appearance of the structure. Choosing the right roofing material is not an easy job because you have a choice of many fine materials, and some of them can be laid several different ways to achieve different visual effects. Your architect or building contractor will select a roofing material that is durable in terms of the cost of the house. But since eye-appeal is largely a matter of personal taste, you should have a say in choosing a roof style that will please you for many years to come.

If you want the ultimate in roofing durability, choose slate, tile, terne metal or copper; but be prepared to pay a premium price for any of these materials. If cutting home construction costs is of paramount

Asphalt roof shingles can give a home the rustic charm of natural materials along with the high durability and protection of ceramic-surfaced mineral granules. Many companies offer a 25-year maintenance-free warranty. Asphalt shingles are classified according to weight. Standard weight shingles weigh between 235 and 240 pounds per 100 square feet of finished roof area. Heavyweight shingles weigh 290 or more per 100 square feet. In the ever changing housing market, asphalt shingles are the most popular.

importance, give special attention to such moderately-priced roofing materials as asphalt and asbestos shingles. But place a sensible limit on your cost-cutting by choosing only those materials that bear recognized seals of approval.

If you live in a hurricane belt, or in dry country where brush fires occur frequently, then look for roofing materials that offer superior wind or fire resistance. Bear one more thing in mind as you consider various roofing materials. Many of them are available in more than one physical form, and some can be installed more than one way; try to pick the best sub-variety and have it installed so that your roof will become a harmonizing architectural asset rather than just a lid on your house.

Asphalt shingles. The most popular type of roofing material for both new and remodeled homes. A good quality asphalt shingle is made up of four distinct layers: a bottom coating of asphalt, next a felt base saturated and waterproofed with asphalt, then another heavy asphalt coating, and finally a top layer of rock-hard mineral granules that impart color and texture to the shingles and also resistance to fire.

Asphalt shingles are classified according to weight. Standard weight shingles weigh between 235 and 240 pounds per 100 square feet of finished roof area. Heavyweight shingles weigh 290 or more pounds per 100 square feet. The heavyweight shingles look more massive, and provide deeper shadow lines and heavier textures than do standard weight shingles. Although heavy shingles cost more initially, they will last longer—up to 25 years according to the manufacturers.

So-called "self-sealing" asphalt shingles have dabs of factory-applied adhesive on the undersides to keep the exposed portions from rising. The adhesive bonding is automatic when roof temperatures rise above 60 degrees F. Although self-sealing shingles

were originally designed for homes built in high-wind areas, they are now used extensively in all parts of the country. More than half of all asphalt shingles sold today are said to be of the self-sealing type.

Asphalt shingles are made in three basic shapes: (1) the most familiar square butt strip shingles that are available with or without cutouts (notches), (2) hex shingles that form hexagonal patterns when laid and (3) individual shingles that are available with interlocking or staple-down tabs.

Choose your roof color carefully since the roof is the largest single visible element of the house. Asphalt roofing shingles are available in many colors including white, black, gray, blue, red, brown and green. When you pick the color of your shingles, bear these general points in mind: light colors tend to attract attention, and in this case make one's eyes look up; thus light-colored shingles are often chosen to add an illusion of height to very low homes. Dark colors have just the opposite psychological effect, hence they are used to make unusually tall or steep-roofed homes look lower. Climate is also a factor to consider when choosing colors. Light colors are best where it is important to reflect the heat of the sun away from the home to keep it cool; dark colors are preferable where it's desirable to absorb the heat of the sun into the house.

Some homes gain visual appeal if the roofing shingles are applied in special ways to achieve more dramatic patterns than are obtained by standard methods of shingle laying. For example, a rugged horizontal roof texture that is especially appropriate for long ranch houses may be obtained by rib coursing the shingles. A triple thickness of shingles is applied to each third, fourth or fifth course. The extra thicknesses create heavier shadow lines, and the roof therefore seems to be sectioned into long horizontal ribbons of roofing. Two-tone rib coursing is similar to ribbon coursing except that two colors, or two tones of the same color, are used. For example, every third or fourth course might have a black starter strip of which only one inch is left exposed when the next colored shingle course is applied. This results in a black band or rib that provides a strong accent to the roof. Two-tone rib coursing is especially recommended for square ranch houses. Heavyweight shingles can be used to achieve the appearance of rough textured individual shingles. There are other ways to apply asphalt shingles to obtain interesting visual effects; your roofing contractor can help you decide which styling would be most appropriate for your home.

➤ *Textured split shakes can open up new, creative roof designs to blend in with overall architecture of your new home. Shakes are electronically bonded to plywood sheathing to form 8-foot panels of bold texture which can be nailed directly to rafters.*

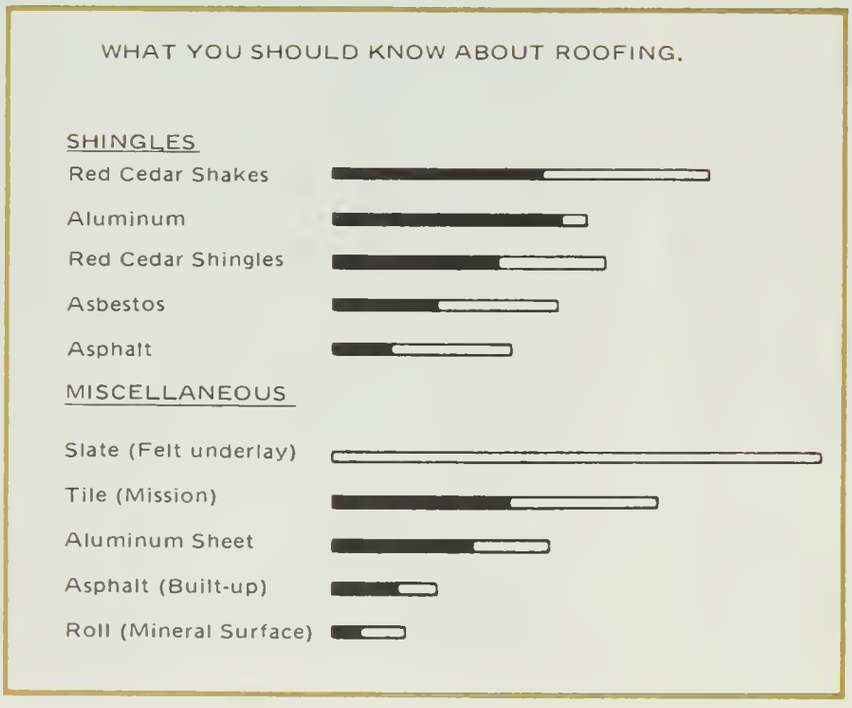
Coverage. A term used to express the amount of weather protection a shingled roof offers. If the shingles are laid so that the overlaps result in two thicknesses of shingle all over the roof, the roof is said to have double coverage. If most of the roof is covered by a triple thickness of shingling, the roof has triple coverage. Incidentally, roll roofing materials provide only single coverage so do not expect such materials to last very long. Use roll materials on outbuildings, like sheds, but not on your home.

The asphalt shingles you select should bear at least a Class C label (Underwriters' Laboratories seal) that guarantees that the shingles meet or exceed certain established minimum performance standards relating to wind and fire resistance. If you live in an area where brush fires are common, consider using UL Class A rated shingles which are designed to protect against severe fire exposure. These shingles contain either asbestos or glass fiber in addition to the usual asphalt, felt and mineral components. Better yet, look into completely fire resistant roofing materials such as asbestos shingles, tile, slate or metal.

Asphalt shingles are suitable for roofs having 4-inch or greater rise per horizontal foot. If the roof is pitched less than that (but at least 2 inches per foot), you can use square butt strip shingles provided they are properly laid to handle the relatively slow water run-off on such roofs.

Asbestos shingles. These are hard-pressed using a mixture of asbestos and Portland cement. They come in a variety of shapes, sizes and colors; some types look much like wood shingles or shakes. Asbestos shingles weigh from 250 to 600 pounds per 100 square feet, and they should be used only where the roof slope is at least 5 inches per foot. The asbestos-cement combination is highly fireproof, and the rigid structure contributes to good wind resistance. However, asbestos shingles are quite brittle and they may crack if walked on or if tree limbs fall on them. Aside from that, asbestos shingles last indefinitely and require little or no care. Asbestos shingles are more expensive than asphalt shingles, but substantially more economical than tile or slate.

Slate shingles. These are completely fireproof, very attractive and very costly. This natural roofing material is quarried only in New England and other eastern locations,



Comparison of relative costs of roofing materials should include labor costs since these can drastically alter total amount. White bar represents labor. Black bar represents material per 100 square feet of roofing. No material cost is indicated for slate since price is greatly influenced by shipping charges.

notably Pennsylvania. Hence, shipping costs for the heavy material can greatly affect prices in more remote areas of the country. Slate is available in many sizes and in a variety of attractive colors including gray, red, green, purple and dark blue.

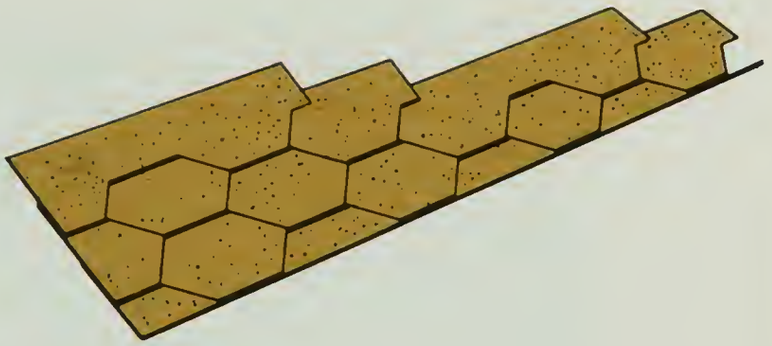
Slate shingles weigh from 750 to 2700 pounds per 100 square feet of laid roofing, consequently you need extra sturdy supports to hold up a slate roof, and this adds materially to your construction costs. A slate roof should be pitched at least 4 inches per foot. Repair of broken slate shingles is quite difficult, usually requiring the services of a roofing specialist.

Clay tile. Clay tile is molded and fired clay. For maximum durability, specify hard-burned rather than soft-burned tile. Since this roofing material is a molded product, there are many different patterns, colors and textures available. Spanish and Mission style clay tiles have pronounced curved surfaces (see diagram). Note that all the pieces on a Spanish tile roof curve outward and that one edge of each tile locks over a flat section on an adjoining tile. On the other hand, Mission tile (also called pan tile) curves in two directions because every other tile is in effect turned upside down and supported on added wood strips.

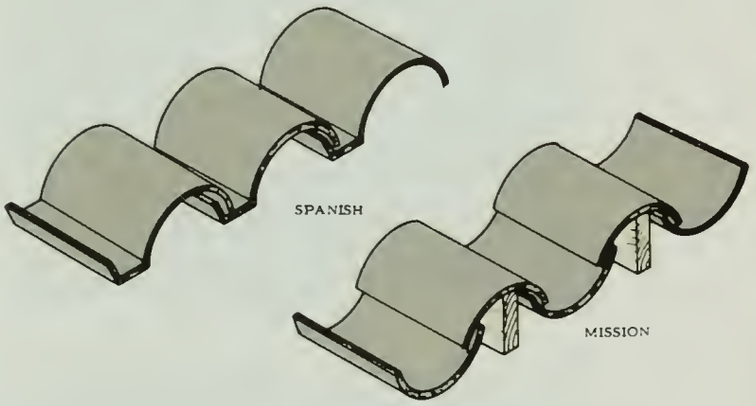
Flat English tile has interlocking edges, Ludowici (French) tile is also flat, but it has two longitudinal grooves added to the exposed surface of each tile to provide extra textural effect.

Like slate, clay tile requires a strong supporting structure because the tiles weigh upward from 900 pounds per 100 square feet of laid tile. The acceptable roof slope depends on the kind of tile used. The more common forms of tile should be used only where there are at least 6-inch pitches; however, some tiles can be laid on roofs having slopes as low as 4½ inches per foot. So-called "promenade" flat tile is used as flooring for roof gardens.

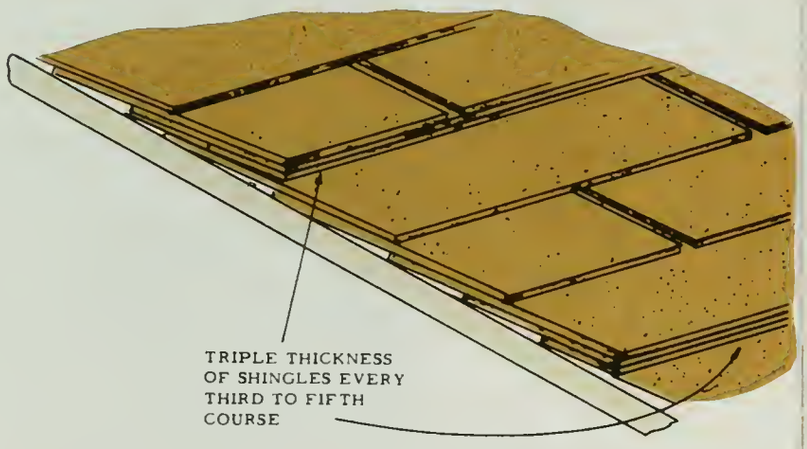
Clay tile is especially appropriate for Spanish or Mediterranean style homes. Tile is attractive when associated with suitable architectural forms, durable, but also one of the most expensive of roofing materials.



Asphalt shingles come in a variety of patterns with many colors to choose from.



Curved surfaces of Spanish clay tile curve outward whereas on Mission style tile half of tile curves inward. Clay tiles also come in many varieties of flat tiles, and shingle tiles.



You can start with one kind of shingle, such as asphalt shown, and lay them many ways for dramatic accents or patterns.

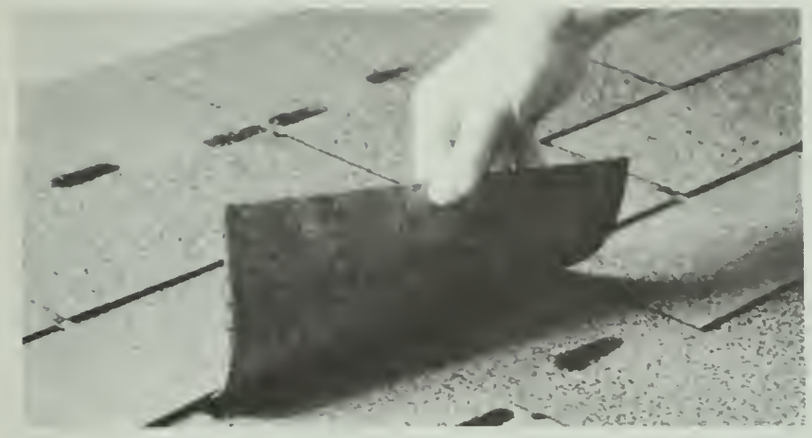
Repairs could be quite difficult, although they would be infrequent unless tree limbs can fall on the brittle tiles.

Wood shingles and shakes. These have been favored roofing materials for hundreds of years, and they still have an aesthetic appeal because many like the textural effects characteristic of wood. However, wood shingles are far less practical than are most other types of roofing. They are now severely criticized because they cannot be made sufficiently fire resistant. In fact, some building codes prohibit the use of wood shingles. If you do use wood shingles or shakes—codes permitting—be prepared to pay higher fire insurance premiums. If your home is located in an area where brush fires are common, or if you are far removed from fire hydrants and from a firehouse, pick a more fire resistant roofing material—for safety's sake.

A 6 to 12-inch roof slope is best for wood shingles, but you can get by even if the slope is only four inches per foot. A well-made shingle roof should last twenty years, especially if treated with preservative stain. However, you can expect to do more maintenance work than with other types of roofing because wood shingles can split or curl. And in damp, shaded areas they may develop mildew and even growths of moss. Wood shingles and shakes are costlier than more preferable roofing materials like asphalt and asbestos shingles. In any case, shakes are preferable to shingles because they are sturdier and because they do not catch fire quite as easily as do shingles.

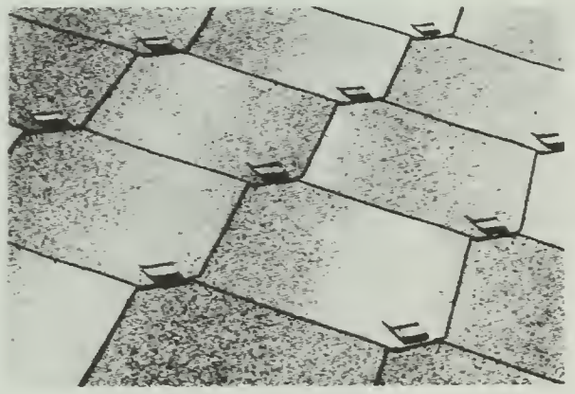
Miscellaneous materials. There are many other roofing materials that you may wish to consider, and discuss with your architect, building contractor and materials sup-

Shake-styled asphalt shingle on this home has popular cedar-textured look, yet one free from hazards of wood roofs. They weigh 345 pounds per 100 square feet of roof area and carry Underwriters' Laboratory Class C label.



With self-sticking asphalt shingles, a pre-applied sealant bonds each shingle along the butt edges to the one below. When selecting asphalt shingles look for the Underwriters' Laboratory seal with a minimum rating of Class C. This means the shingles meet certain minimum performance standards relating to wind and fire resistance. If you live in an area where brush fires are common, consider using UL Class A. These shingles contain either asbestos or glass fiber in addition to the usual asphalt, felt and mineral compounds.

Shingles have many different ways of locking. These heavy-duty, self-locking shingles provide double coverage over entire roof. Design allows each shingle to interlock with adjacent shingle in four different places to result in tight roof.



With this shingle, key-shaped tab is nailed to roof. Slot in shingle in course above is fitted over lower end of key, then pulled up tight and nailed. Even hurricanes have failed to budge this type locking shingle.

plier. Some are used only on certain types of homes that traditionally call for specific styles of roof treatment. For example, homes reflecting classic traditions may call for at least limited use of metals such as copper, aluminum, lead, nickel-copper alloys, steel and terne plate (lead-tin alloy). Copper is long lasting, and it weathers to a very pleasing, soft green color.

Unfinished aluminum lasts for a long time provided it is not used in salt air locations. However, the shiny metal is decidedly unattractive on a home, although it may be acceptable on a barn or other outbuilding. Thus aluminum should be painted, or you should use aluminm shingles that have been pre-finished at the factory with baked-on enamel coatings. Such aluminum shingles have not been in use long enough to permit evaluation of their long-term durability.

Corrugated fiberglass roofing has its place in home construction since it is highly corrosion proof and resistant to impact. Translucent varieties are especially good as roofing materials over patios and other outdoor living areas because, besides providing protection from inclement weather, they transmit enough diffused light to keep the area cheerfully illuminated.

Flat roofs may be covered with sheet metal, rubber compounds or other materials. The most common treatment—the

built-up roof—consists of covering the roof surface with alternate layers of hot liquid asphalt and felt or building paper, then topping these materials with a layer of gravel, marble chips or slag. Built-up roofing should be used only on flat surfaces; if there is even a slight slope, the asphalt may soften enough in the hot summer sun to run down the wall of the house. Moreover, on a sloped roof, the topping gravel tends to flake off and accumulate in rain gutters.

A built-up roof is not for walking or lounging. If you wish to use the roof area as a sun deck, use a rubber surfacing material made for that purpose, or add a separate wood deck over the roof. Canvas is a traditional material for covering sun decks, but it does not last as long as might be desired even if periodically re-conditioned.

New roofing materials appear on the market periodically, and they deserve consideration, bearing in mind that since they are new they cannot have been subjected to long-term tests under actual weathering conditions. Even plywood is now used as a roofing material by coating it with special plastic materials. Some contractors reportedly guarantee such plastic coated roofs for as long as ten or fifteen years. Re-coating after that period of time should be neither difficult nor exorbitantly costly. J.H.

See also: HOME IMPROVEMENT; HOME OWNERSHIP.

The wood shingles on this home consist of 16 individual cedar shingles bonded electronically to the plywood sheathing to make an effective 8-foot panel. No skilled labor is required for application since both shingles and sheathing are nailed directly to rafters. Check local building codes because in many areas use of wooden shingles is prohibited due to local fire-safety codes.

Repairing Roofs and Gutters

Periodic inspections and prompt attention to small flaws will stave off the professional repairman's visit for many years

TAKE AN HOUR and get to know your house. Climb a ladder and take a look at the roof. Examine the siding. Get to know the house around you. It can and should be kept tight and sound with regular, minimum upkeep, at little cost. The average homeowner can do these minor things, prolonging the life of the house and avoiding the higher costs of professional help.

Roof shingles. In all but faulty installations, shingles will last for years requiring little or no maintenance. As they begin to age, however, individual shingles will curl and strong winds will lift them. Sometimes they break or stay curled up. They must be either flattened or replaced, as rain driven by winds will shortly get under the other shingles and begin to deteriorate the sheathing or sub-roof.

All the material this requires is a can of black roofing cement, a box of annular roofing nails, a putty knife, and a hammer. Plus, the replacement shingle, if any, available at the building materials supplier.

For lifted shingles, dab the underside with roofing cement and press it down. If the shingle is torn but in one piece, do the same thing—then apply more cement to the crack line. If the shingle is in two pieces and the separated piece is available, dab it back in place, drive two or three roofing nails along the tear line, and add more cement to both the tear line and the nail heads. Always cover exposed roofing nail heads with cement.

If a torn shingle has to be replaced, the process is simple, if a little awkward at first.

The remaining half of the shingle has to

be removed. It can probably be pulled free, leaving only the nail heads. The nail heads, up and under the overlap of the neighboring shingle, can be removed with a long-shaft screwdriver—or, simply, drive them all the way into the roof, hitting the shingle overlap.

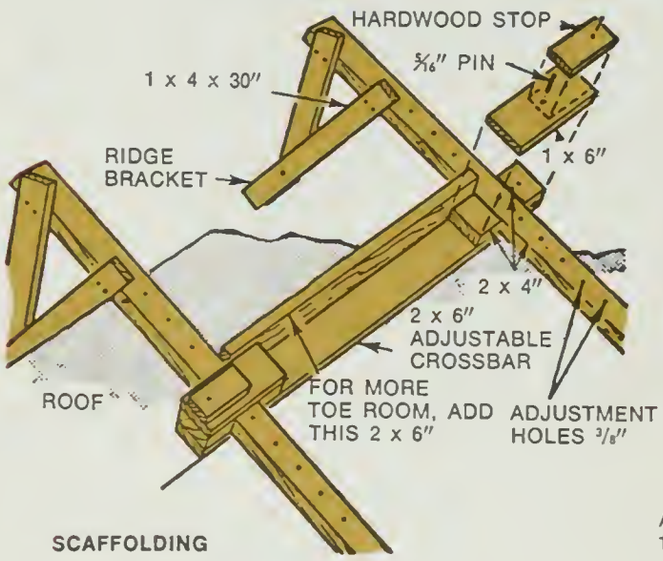
Now the replacement shingle can be slipped into place and correctly positioned (align it with the adjoining shingles). Ideally, new roofing nails should be driven in at a point as far up the new shingle as possible—but this necessitates bending the overlapping shingle to a degree that may crack it. There are three options. Drive the nails at a lower point, but still under the overlap. Use the shaft of a heavy screwdriver as an extension (clumsy, but it will work). Drive the nails through the top of the overlapping shingle, into the new one under it (dab the heads with cement).

For the next maintenance step, examine all the flashings—the seals that wrap around the chimney and vent pipes, and the seals in the roof valleys (where two sections of roof adjoin). This is usually sheet metal cut and shaped to bridge the gap created by the protruding vent of chimney and the cut or notched portion of the roof. The flashings or metal is also overcoated at the edges with roofing cement. Ordinarily, the flashings will hold firm but the cement in time dries and flakes away, and the exposed edges catch rainwater. Therefore. all suspect flashings should be periodically coated with roofing cement to assure a good seal. If the flashings themselves appear loose, they should first be nailed, then coated.

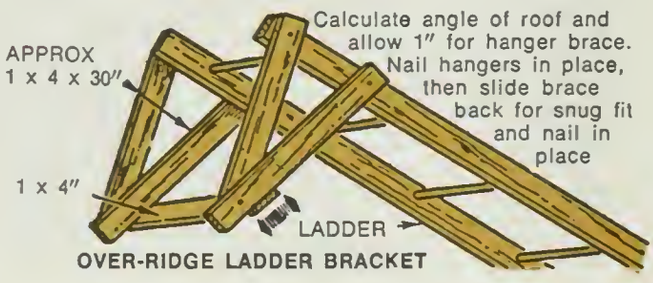
Flashings in roof valleys are for the most part concealed by the valley shingles. Only when a shingle curls or is torn should you poke under it to determine if the flashing is sound. Repair with roofing cement and, if necessary, roofing nails. Hip shingles (the reverse of valley shingles) may tend to crack or separate as the years go by; they, too, can be dabbed at all the crack lines with roofing cement. If the deterioration is severe, it is a simple matter to cap the area with a new, replacement, hip shingle.

Inspect every foot of the roof gutters. The gutters themselves should be clear of accumulated debris, especially at the drain that feeds the downspout. It's a good idea, too, to clear out the scattered leaves and twigs, as the next rain is sure to carry it all to the drain, where it will probably clog. Cap the drain with wire mesh screening—or, better still, install wire mesh strips over the gutter troughs. This allows the water to flow and drain freely; leaves on top of the screening will eventually blow away.

Examine the firmness of the gutters. Where they are wobbly or unsound, use roofing nails to re-anchor them. Coat the



This roof creeper, for use on all but extreme-pitched roofs, makes a good working platform. Calculate the angle of the roof and allow 1 inch for hanger brace. Nail hangers in place, then slide brace for snug fit and nail in place.


Calculate angle of roof and allow 1" for hanger brace. Nail hangers in place, then slide brace back for snug fit and nail in place
APPROX 1 x 4 x 30"
1 x 4"
LADDER
OVER-RIDGE LADDER BRACKET

➤ *Faulty flashings, the seals that wrap around the chimney and vent pipes, can be resealed with roofing cement and if necessary, repaired with roofing nails.*

exposed nail heads. Just be sure in repairing loose gutters that the pitch (downward, about 5 degrees) is maintained in order to drain the water.

Next, the downspouts. These should be clear of matter. If not, they back up (a stoppage at a low point could back up enough water weight to cause the downspout to come loose or fall), causing gutters to overflow, battering plantings below with sheets of roof water.

The hangers should also be tested for soundness. These hold the downspouts firmly to the siding; they also hold the downspout firmly against the gutter outlet (loose downspouts usually separate from gutter drains and the water just sprays downward). Loose hangers or straps can be re-nailed, or they can be replaced as easily with a new one.

The troughs of old gutters can be coated with roofing cement in order to extend their life.

Siding. The key to well maintained house siding is a good paint or stain finish. If the finish is in good repair, the siding materal —shingles, shakes, clapboard, whatever— will be well protected and relatively free of problems.

A thorough siding inspection begins at the roof line. Look for staining (signs of water being driven into any roof-siding separations by wind), warping, shingle or board separations, paint cracks or flaking, and rusty nail heads. These could be early signs of future damage.

Wherever there is staining, test the area

➤ *Check flashing material around the chimney where cement may have dried and flaked away. Pry up shingle to determine if there are tears underneath.*

Deteriorated roof trim should be replaced or at least strengthened with roofing nails and repainted with the proper paint for the job.

Examine the firmness of the gutters. Where they are wobbly or unsound, use roofing nails to reanchor them.

Gutters should be clear of accumulated debris, especially at the drain that feeds the downspout.

Corroded gutters can be temporarily repaired by coating the interior with paint or roofing cement. Be sure to maintain pitch for good drainage.

with a nail or ice pick to determine if the wood is soft or deteriorated. It would pay to scrape away some of the finish in order to see how severe it may be. If it is local only, let it dry thoroughly, add an extra nail for firmness, then re-seal and touch up with paint. If it is a bad section that is far gone, a carpenter may have to be called.

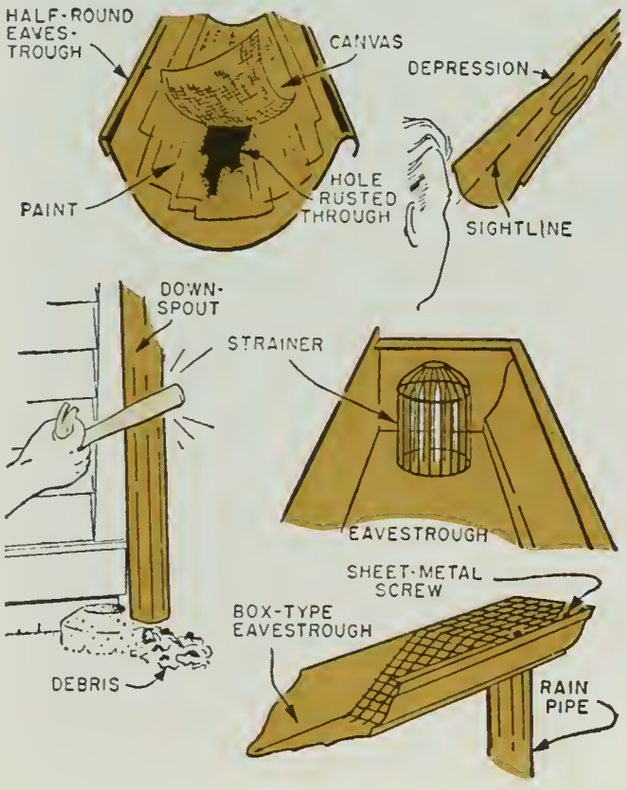
To remove and replace a shake, shingle, or section of clapboard requires some dexterity.

Shakes and shingles are handled in approximately the same way as roof shingles. Pull the nails or shear the heads of nails. Position the new shingle and nail. In the case of asbestos shingles, there will be a pre-drilled nail hole to serve as a guide; if not, drill one—do not attempt to hammer a nail directly through asbestos.

Sections of clapboard can be cut with a backsaw. It doesn't matter at what point along the line. It will be awkward, but the idea is to saw on the flat of the board in short strokes, up to the next overlapping board. When the board is cut through at the two end points, snap out the soft section up to the overlap. The portion of old board left under the overlap has to be chiseled out, a job which will take some patience. The old nails will have to be sheared after all of the old board is out. After that, cut and position a new board section, nailing it through the new board section. Countersink these heads and putty the holes. Re-paint or re-stain the new section.

Whenever removing a shingle, shake, or section of clapboard, it's a good idea to examine the interleafing black (builder's) paper to be found underneath. If it, too, has deteriorated, peel it off and examine the wood sheathing. If the wood sheathing is water damaged, then this is the time to call in a carpenter for a professional repair. If the sheathing is dampened in a minor way only, allow the exposed section to dry thoroughly (rip out as much as you have to in order to confirm the extent of the dampness), then install new paper and new siding.

See also: ADDITIONS, HOME; CAULKING; CHIMNEYS; HOME IMPROVEMENT; PAINTING, HOUSE; SIDING.



Resurfacing a Flat Roof

Flat roofs require more care than sloped ones, but any householder is capable of patching or resurfacing one himself

ALL TYPES OF ROOFING take a beating from the combined effects of sun, heat, rain, wind, and freezing cold, but none more so than a flat roof. There are two causes for this—rain and sunshine.

A flat roof cannot shed water as easily as a pitched roof does (a flat roof is any roof with a pitch of less than 23 degrees). It cannot be covered with shingles for this reason—that is why flat roofs are relatively unattractive black surfaces of tar. The sun bakes this roof coating. Depressions form and water collects. Bubbles form and the skin splits. In time, these weak points erode and water enters. After that, the roof problem also becomes a ceiling problem in the room below. Unattended, the flat roof will continue to worsen progressively. At the very least, it needs a quick patch job. But the best bet by far is to re-cover the troubled roof, a job which may be easily undertaken by the average homeowner.

The basic materials include rolls of heavy roofing felt, roofing tar, roofing nails, and a roll of aluminum stripping about 9 inches wide. For tools, you'll need a ladder, a hammer, an applicator brush with a long handle, a wallboard knife (for cutting the roofing felt), and a heavy pair of scissors (metal shears are not necessary) for cutting the very lightweight aluminum. When you go to the hardware store or building supply dealer, make a note of the area to be covered, as this will be a guide to the quantity of felt and tar needed for the job.

The project shown here is a typical flat roof, pitched to about 10 degrees. In addition to having developed a break in two places, there were two other signs of trouble. Water stains at the joint where the roof and the shingle siding met indicated that wind-driven rain was settling in the unprotected joint. One edge of the roof also showed signs of deterioration through lifting and edge-curling of the old covering.

One of the first steps in the repair was to install a strip of flashing (the aluminum) along the deteriorated edge using the roofing nails. This strengthened an otherwise weakened edge. Working from the outside limits inward, the first coat of tar was applied to one roll-width of the roof, includ-

The weakened edge of the roof is strengthened with a nine-inch wide strip of aluminum flashing, using even-spaced roofing nails.

New roofing felt is applied along the front edge of the roof. It is then nailed every three or four inches lengthwise along edge.

A wallboard knife is used to trim the edge of the roofing felt to be flush with the aluminum flashing edge, for a professional look.

Tar is applied for the second strip of felt, both on the old roof and overlapping the first strip of felt about one-third width.

▲ *When the end of the first roll of felt is reached, midway during the job, the edge is secured with roofing nails evenly spaced.*

▲ *After tarring the secured end, tar is applied and the new roll is overlapped. The leading edge is secured with nails, as in last step.*

▲ *The third roll of roofing felt is unrolled. Note that each roll is generously overlapped and a margin has been left at edge for trim.*

▲ *To thoroughly seal the joint, the aluminum stripping is shaped into a cove molding and slipped under the bottom course of shingles.*

in a good smear on the newly installed flashing. This done, the first new roll of felt was unrolled and nailed every three or four inches along both sides. The end was trimmed flush with the edge of the roof, using the wallboard knife.

Thereafter, tar was applied for the second strip of felt, both on the old roof and overlapping the first strip of felt. When the first roll of felt came to an end midway in the repair, the end was well secured with roofing nails. More tar was applied to this

▲ *The bottom edge of the aluminum flashing is nailed directly into the new roof covering, and the edges are given a first seal of tar.*

▲ *A final overall topping of tar is applied, giving particular attention to any exposed nail heads and to areas that need extra tar.*

secured end, and when the new roll was started, it overlapped the end of the old roll. More roofing nails secured the leading edge of the new roll.

Subsequent rolls of felt over fresh tar followed until the last roll was laid, flush in the joint where the new covering and the shingle siding met. In order to thoroughly seal this joint, the aluminum stripping was shaped into a cove molding and installed in the joint with the top edge slipped under the bottom course of shingles. The bottom edge of flashing was nailed directly into the new roof covering, and the edges given a first seal of tar.

After the installation was complete, a final, overall topping of tar was applied, with particular attention to exposed nail heads. This finished the job.

Although the pitch on this roof was only 10 degrees, it was and is necessary to recover all flat roofs, regardless of pitch, in overlap fashion—as you would overlap pitch-roof shingles. This arrangement does not give water any edge to collect against, however slight the pitch may be.

After a short period of time, perhaps a month or two, a few nail heads may pop up. This will not be due to any fault in the re-covering process—it is because these nails happen to have been driven between two boards and have no purchase. Simply tap them back into place and dab the broken skin with more tar. Better still, use a roof patching compound that contains some asbestos particles. This sealer will ooze into whatever breaks the popped nail caused and will be stronger in the long run.

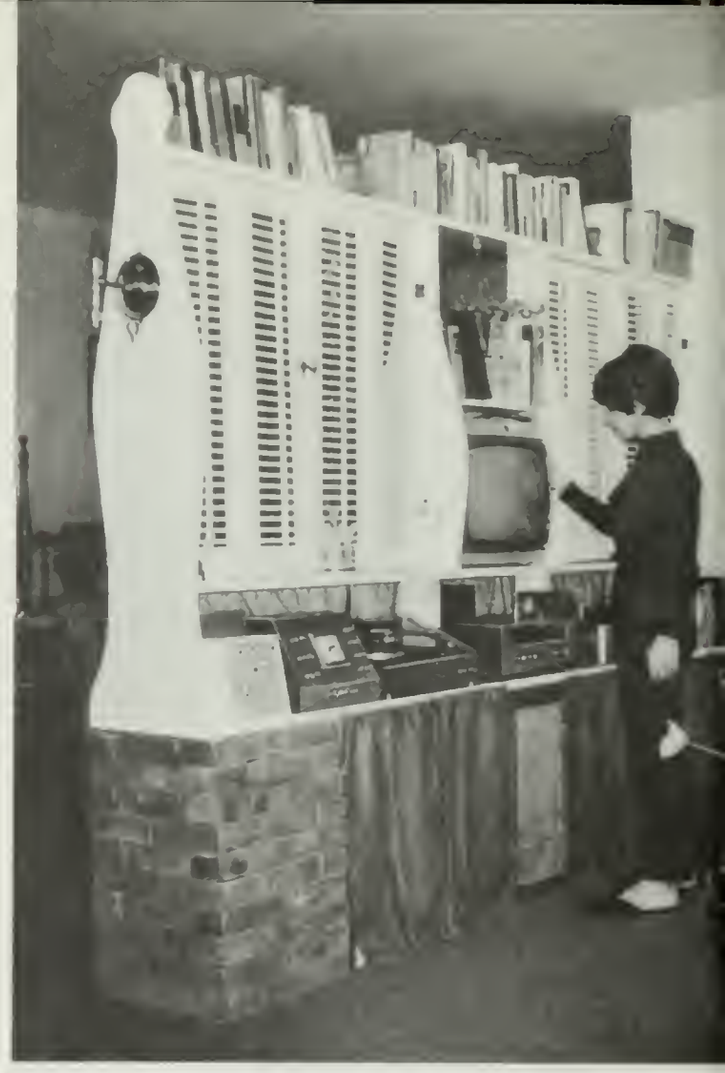
It wouldn't hurt to re-coat the new roof job seasonally. Once a year will do, in the fall or spring. This will extend the life of the basic repair and add a neat appearance.

If accidental breaks occur (a tear from a heavy tree limb or the feet of a sharp metal ladder), a good patch may be made with materials left over from the big job. Following the same basic plan, coat the tear and the surrounding area with tar, place a patch over it, nail the edges all around, and add a final top coat of tar. This kind of repair is every bit as good in technique as the basic re-covering. B.M.

See also: CAULKING; CHIMNEYS; PAINTING, HOUSE.

Use Louvered Panels to Divide a Room

This design increases the privacy available in a studio apartment, but permits the passage of air and some light



NEVER HESITATE to be your own interior designer. Laying out the living space in a typical efficiency apartment violates the floor plan suggested by the builder, but results in an apartment with more function, more charm and a multi-room feeling for much less rent than would be demanded for a two or three room apartment. By the same token, a large room or the basement of your home can be similarly divided.

The secret of design is this louvered room divider. It can be placed in the one large room, as shown in the floorplan.

Dividing one large room into a living room and bedroom poses the problem of designing a room divider that will not block all the available light from the living room. A folding screen type divider that could be pushed back for light in the daytime is one idea. But this would be a non-functional wall. The louvered room divider offers shelves or storage space, and the aesthetic appeal of a more permanent and less obvious dividing wall. Another advantage of the room divider is its impermanent nature. This room divider is inexpensive to build and can be dismantled when you move. If you can't use the room divider as it stands in a newly acquired home, you can use the louvers on the kitchen windows, the lumber in the workshop, and the bricks in the garden.

The warmth of red brick is unmatched; it's a natural with American colonial or any type of country furnishings. It's the perfect structural base for the room divider. Two hollow columns of bricks are placed at either end of the divider as shown in the detail drawing. A total of 120 conventional 3⅝ x 7⅞ x 2¼-inch red bricks are used. Laid as shown, no mortar is required. Note that a center speaker for the hi-fi system—housed in the room divider—provides the support required in the center. If you do not integrate a similar structural piece into the room divider, a third column of bricks or other support will be necessary.

The center compartment of the room divider is especially dimensioned for a portable television. The space should be adequate for most portables. After determining the width of the center compartment and subtracting it from the 8-foot length of the

root cuttings: see gardening
root feeding: see gardening
root pruning: see bonzai
rope: see knots
roses: see garden planning

divider, you can plan the arrangement of the louvers on each side. The louver panels, available at almost any lumber supplier, come in various heights; those shown here are 36 inches high. Various widths are also available. In this divider, four 9-inch wide louver panels are used on each side. Only slight trimming is necessary. Two louver panels are hinged together for each side of the opening and hinged to the vertical members. This arrangement allows the louver panels to be hinged back flat against the sides or to be hooked shut in the center. When the louvers are latched closed, they can be either left in their open position or closed for complete room division.

Printed fabric to blend with the room decor is used on the lower portion of the room divider, across the back of the lower shelf, and behind the television. The television can be mounted on a lazy Susan and then be swiveled to face into the living room or the bedroom. The fabric, therefore, can be hung on the side of the divider where the back of the television would otherwise be exposed.

The bedroom side of the lower shelf behind the high-fidelity components houses all the wiring. The fabric allows the connecting wiring to be hidden from view, and also allows very easy access to the rear panels of the equipment for making connections. The fabric across the lower half of the divider can be pushed back to expose plenty of storage space for phonograph records, large books, or anything you want to tuck out of the way.

Following the detail drawing, construction of the room divider should pose no problems. The pine base shelf, 15¼ inches

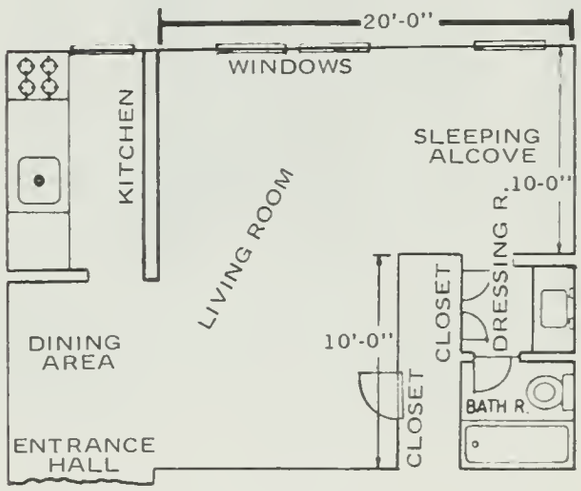
Hinged louvers can be unlatched and then swung open, as shown in this photo.

The portable television faces into the living room; it can also be rotated to face bedroom.

by 94½ inches should preferably be cut lengthwise down the middle and the two halves turned to reduce the effects of warping. The framework of the room divider can be joined with glue and wood screws using simple butt joints. After-cutting the end supports to shape with a saber saw using the grid in the detail drawing to plot the curves, countersink the screws in the exposed end support, fill with wood filler and sand smooth.

Once the framework is complete and squared, the louver panels can be trimmed for precise fit. Before mounting the louvers in the framework, finish the framework and the louvers in the paint or wood stain you prefer. A coat of flat white and another of white satin finish enamel were used for the divider as shown here. (Unless you spray the louver panels, prepare yourself for a very time consuming job doing them with a brush.)

If the louvers are finished in a walnut or other wood stain, you can achieve a very compatible effect with the bricks. However, the dark finish detracts from the overall level of room illumination. An antiqued finish in one of the many available antiquing



Original efficiency apartment layout is only non-functional wide open spaces without divider.

With room divider placed as shown, apartment assumes a distinctively charming decor.

Construction details on opposite page for the louvered room divider show all dimensions including those for the curved surfaces. Working to close tolerances will minimize gaps around the louvers and framework.

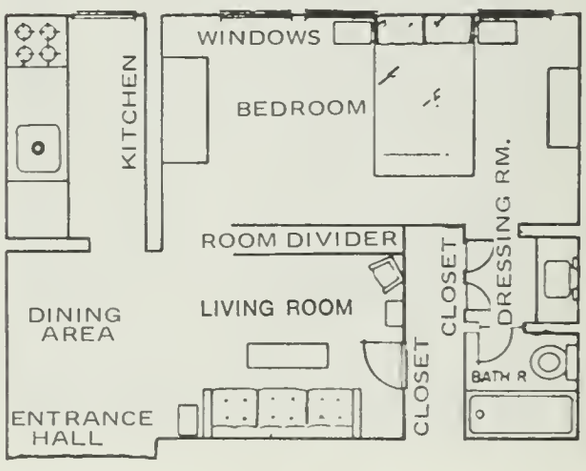
kit colors can also put a masterful touch on the appearance of the divider.

The louvers can now be hinged and hung in the frame. Take great care to align the hinges properly so the louvers will swing clear and meet square with the proper clearance between them. The curtains, which are easy to make, can be hung on thin brass curtain rods; or, instead of commercial rods, you could even use coat hanger wire.

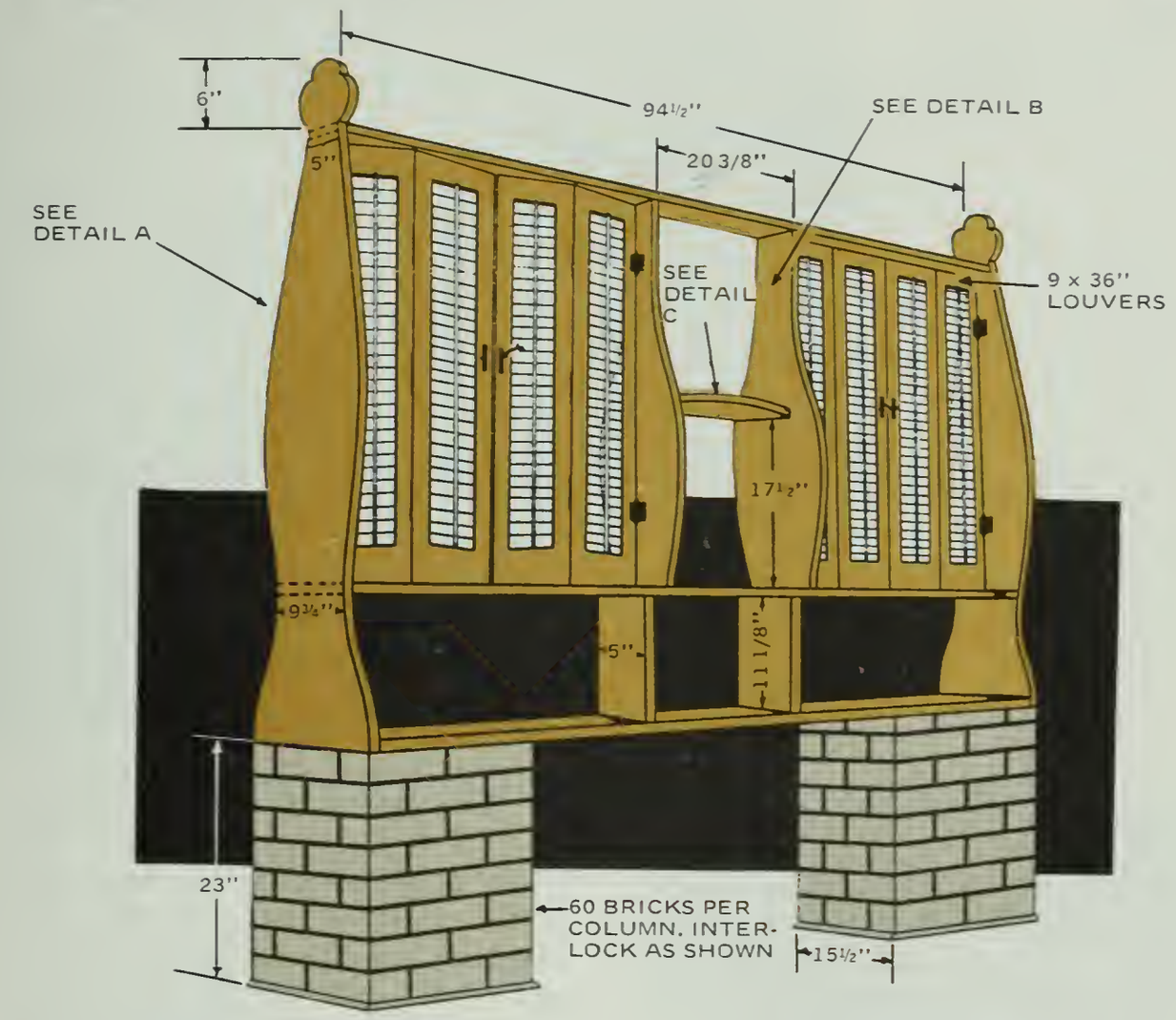
You'll encounter remaining final details as you furnish the room divider. The television, for example, cannot be used with its pull-out antenna due to the shelf above it. But, antenna lead-in wire from a roof antenna can be run up to the antenna terminals by drilling a hole in the base shelf next to the television. The power cord can be run through the same hole and, with an extension cord, plugged into a convenient outlet near the divider.

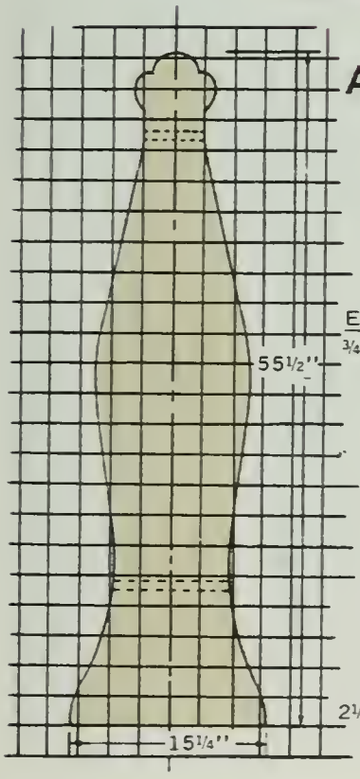
The top and bottom shelves of the room divider will hold a wealth of books, nicknacks, hi-fi equipment, or what have you. Just finish it off to suit your own particular tastes and needs, and relax in one of your new rooms. B.H.

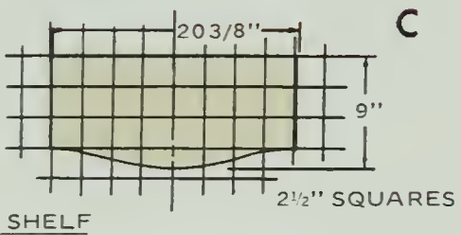
See also: PANELS; PARTITIONS.



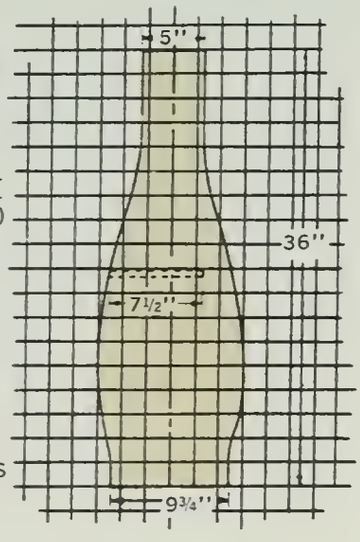
Use Louvered Panels to Divide a Room 2195







CENTER SHELF
¼" PLYWOOD



CENTER SUPPORT
¼" Plywood (2 req.)

2" SQUARES

LOUVERED ROOM DIVIDER

Mini Wankel for Model Airplanes

This tiny rotary engine delivers 1/2 horsepower, weighs 11 ounces

YOU CAN BUY a rotary-engined Mazda car today—and both Chevy and Ford promise to have home-grown "Wankelwagens" on the road. But, according to industry sources, general use of RC (rotary combustion) powerplants in automobiles is probably still a decade away.

Long before then, the rotary should be well-established in the small engine field, powering things like snowmobiles, go-karts, motorcycles, minibikes, outboard motors, garden tractors, lawn mowers, chain saws, hedge trimmers, snow throwers, portable genators, and radio-controlled models.

Right now, many manufacturers of such items have Wankeled versions in the works —under development, if not actually in production. These firms have joined the "Wankel Club" because they recognize the RC motor's considerable advantages—compared to a conventional reciprocating engine of like power—for their particular applications.

With about 40 percent fewer parts, the rotary is simpler, as well as smaller and lighter. Easier to start, it's quieter and lots smoother (almost vibrationless) in operation. At least potentially, the Wankel is more economical, too.

The world's smallest Wankel is the OS/ Graupner Wankel .30 model airplane engine. It measures 2¾ inches in diameter and 2½ inches front to back, overall. Weight is approximately 11 ounces (the muffler adds 1¼ oz.)—just about the same as for a reciprocating engine of equivalent output—approximately ½ hp.

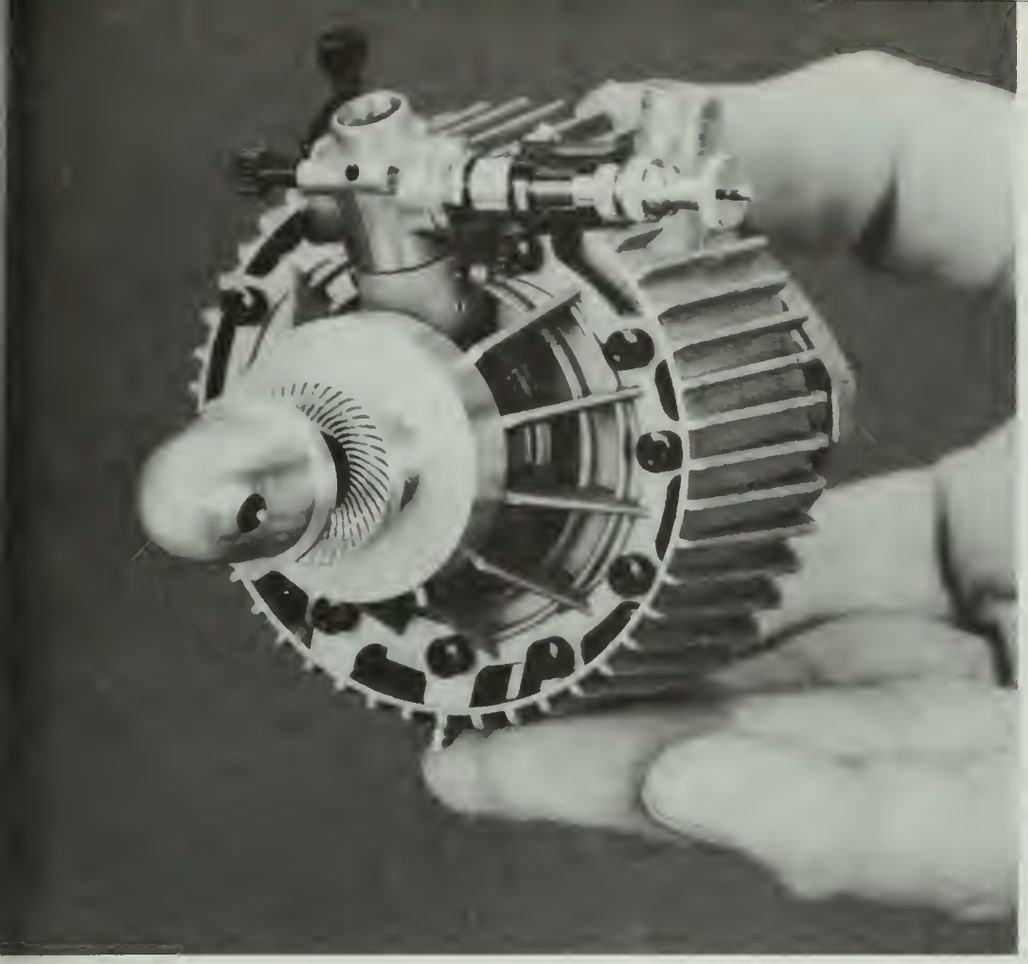
Essentially like its full-size cousins, the Graupner Wankel is an air-cooled, single-rotor engine of .30 cu.in. displacement. It has a glow-plug ignition system and a throttle type carburetor and runs on standard methanol-based model fuels.

The Graupner Wankel .30 outperforms most .40's on the market—a peak output of 0.67 hp at 16,000+ rpm has been reported. Owners give it high marks for handling ease, too. Compactness and mounting convenience adapt this engine to a wide variety of radio-controlled or control-line model aircraft.

To translate the Wankel principle into an efficient powerplant the size of a tangerine takes clever design and precision workmanship of a very high order, so the cost is relatively high. P.W.A.

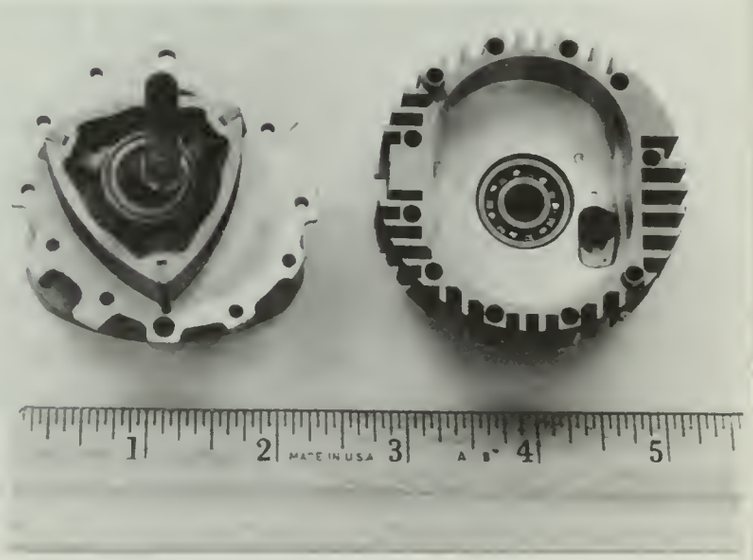
See also: AUTOMOBILE ENGINES, ADVANCES IN.

rotary engine tune-up: see tune-up, engine
rotary engine, wankel: see automobile engines, advances in
rotary files: see drill press
rottenstone: see abrasives



OS/Graupner Wankel is about the size of a small orange.

External accessories for the OS/Graupner Wankel include a cooling ring (top) to dissipate heat, a muffler (left) for quiet operation, and the slide-throttle carburetor (on the right).



Disassembled one can clearly see the triangular rotor and oddly shaped "epitrochoid" chamber, which is very difficult to machine. OS Wankel has spring-loaded metal "apex seals" at each rotor tip (the Wankel equivalent of piston rings). Ball and needle roller bearings are among this engine's precision features.

What You Can Do with a Portable Router

You can use this versatile power tool to groove, dado, rabbet, cut freehand designs, make dovetail joints, inlay veneer or make decorative molded edges. With easily made jigs and fixtures it can do extremely accurate work rapidly

IDEAL FOR JOBS too large to be handled on stationary power tools, the portable electric router with its variety of cutter bits and attachments becomes a versatile power tool capable of routing, drilling, shaping, carving, planing and even cutting through ¾-inch stock. Because of its extremely high speed of rotation (14,000 rpm and over), the router makes smooth cuts that in most cases require no sanding. While the weight of a portable router may run anywhere from 6 to 30 pounds, depending upon type and size, it is easy to handle because the work supports it.

With a shaper table, you can use the router as a standard shaper (vertically or tilted); with a special attachment and spiral cutter, as a portable planer useful for jointing edges of large jobs. Also, grinding jigs permit sharpening of cutters with grinding points mounted on a router.

A router consists of a motor held upright in a base, the threaded spindle carrying a collet chuck. A sub base and various guides are provided. Depth of cut is regulated by rotating the motor in the threaded or spiral-channeled waist of the base, or on some machines with a rack and pinion mechanism.

Rabbeting is a typical use of a portable router. To set it up for this operation, insert a router bit or a special rabbeting cutter in the router chuck, stand the machine on the board to be worked, and adjust the bit to touch lightly on the wood. Set the cali-

router bit: see drill press
routers: see power tools
routing: see radial arm saw
rowing machine: see exercise equipment
rudder: see emergency boat repairs

brating sleeve or ring on the router to zero position, lock it, and lower the bit to depth of cut. When cutting large rabbets it is better to make two or more light cutting passes rather than one heavy cut. Next, mount the guide on the router with the straightedge toward the cutter, measure the distance from the guide to the far edge of the cutter, and clamp the setting. For end rabbeting, press the guide against the end of the board, and feed from left to right at such a rate that the free motor speed is not slowed down more than about one-third. Too fast a feed overloads the motor; too slow a feed burns the wood, and may soften the cutter.

A close fit between the cutter and the guide opening is desirable when rabbeting, so that the beginning or ending corner will not enter the gap, causing the router bit to gouge. A wooden strip 8 or 9 inches long and ½ to 1 inch thick screwed to the guide will prevent such difficulty. The cutter will make its own recess in the facing as the bit is lowered to cutting depth.

Hold the board between bench stops, by clamping to the top, or if thick enough, by gripping it in the vise, the end to be rabbeted projecting a little. A strip of scrap wood clamped to the following edge prevents splintering as the cutter emerges, and one at the other edge helps. Where two or more pieces are to be rabbeted, line them up edge to edge. If an end and edge are to be rabbeted, do the end first, so that the edge cut will trim off the splinters. The board can be rabbeted all around in one continuous cut.

Rabbeting of an inside edge of a box or frame has many uses, as in making a window screen, where the frame can be joined with butted joints and dowels, and rabbeted for the screen mold afterward. Screw a 90° angle guide block to the router guide if it has no pointed end and move around against the rotation of the cutter. Trim the rounded corners square with a hand chisel.

Stopped rabbets are made by feeding the cutter up to a marked point, or if stopped at the beginning of the cut by feeding in from that point. Accuracy is automatic if a block is clamped on the edge to contact the end of the guide, a precaution especially valuable to prevent kickback when starting a stopped rabbet.

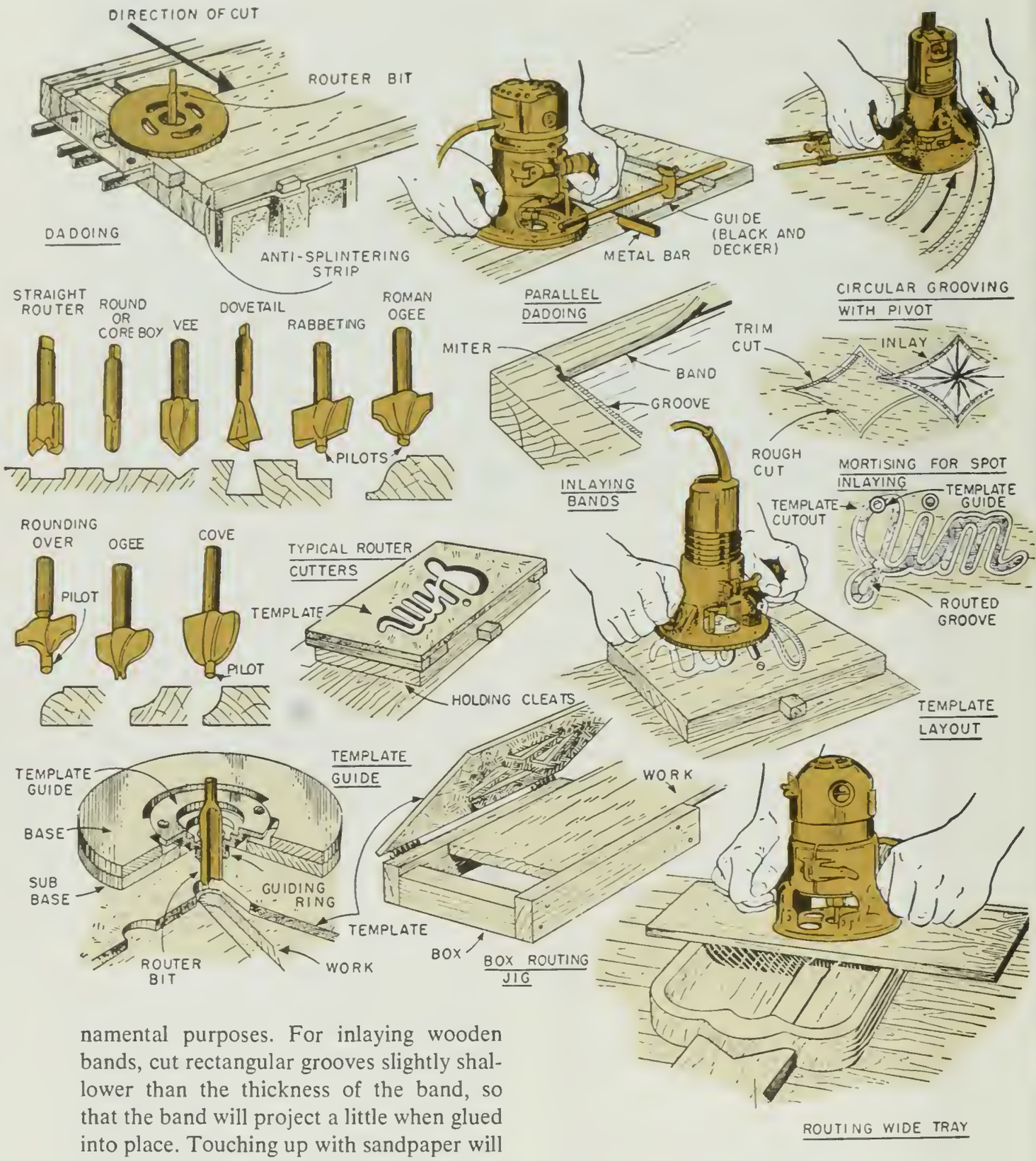
To rabbet the edge of a disc, remove the straight guide from the fixture and use the vee-end guide against the work. Instead of the vee guide, a wooden guide facing shaped to the curve of the disc can be used. This type of guide will produce smoother work.

Dadoing and grooving are operations similar to rabbeting, the guide being used in much the same way. Choose a router bit of diameter equal to the width of the dado desired and set it for depth as in rabbeting. Anti-splintering strips at the edges should be used. In heavy work, make two or more passes. If a groove wider than the cutter is needed, first cut one side, then extend the guide setting and make another cut, repeating until the needed width is gained.

Instead of using the guide fixture, a strip of wood clamped to the work for the router base to slide against can be used. This is necessary if the dadoes run at an angle to the edge of work. When a series of parallel dadoes are to be made, cut the first one, then shift the guide or the straightedge and cut the next one and so on. With one form of router guide, a metal bar enters a previous cut, bearing against the near edge.

Circular grooving of a disc is done with the vee-guide or by means of a trammel point clamped to the guide rods and pressed into the work. This pivot method is especially handy where the circles are not concentric, or if the piece is not round, providing no guiding edges.

The bottoms of grooves can be rectangular, vee, or rounded, according to the type of cutter used. Narrow and shallow grooves are called veins, and veining is used for or-



namental purposes. For inlaying wooden bands, cut rectangular grooves slightly shallower than the thickness of the band, so that the band will project a little when glued into place. Touching up with sandpaper will cut the band down flush with the surface, without need of sanding the whole surface.

Irregular inlays, such as the spot ornaments often used in the centers of tables, are mortised in using the router freehand or with the use of templates. To cut the recess, trace around the inlay with a sharp knife point and route out the work again a little shallower than the thickness of the inlay.

Use the router guide to achieve a straight cut when routing a groove.

Operate router freehand to carve a design in the surface of a piece of stock.

Start the mortise near the center and trim toward the lines. Insert the inlay with the paper side up.

Freehand grooving is sometimes used for making signs and nameboards. The groove can then be filled with Plastic Wood or other composition to resemble inlaying, or the background painted a color contrasting with the lettering. To rout out names or designs accurately, or if there is to be duplication, make a template from hardboard or ¼-inch plywood. The working size of the template depends on the bit and guide to be used. The template guide, through which the router bit is inserted, is a small cupped disc having a thin-walled ring slightly larger than the router bit to be used. A good bit to use for this work is a ⅛-inch diameter left-hand twist router. When making a template, first draw the design on paper, and then sketch in a larger outline to allow for the extra diameter of the guide ring. Transfer this to the template material and tack it to a scrap board which is clamped to the bench. Set the router bit for a projection of about 1/16-inch below the template,

and trace around the inside of the design outline freehand with a rather rapid feed. Then, at slower feed, take a second cut, carefully trimming to the design line. Since

Carving a decorative molding edge. The round stem at the end of the cutter is called a pilot. It rides along the uncut bottom edge to keep the router cut true.

Router motor and bit move within the threaded waist of the holder. Rotating the holder in relation to the motor moves the bit in or out for depth adjustment in this model, although there are other types that use a rack and pinion system. The window scale here is for relatively large depth adjustment. Fine adjustment is measured on the ring. Each tick mark represents a quarter of 1/64-inch.

any irregularity of the template is transferred to the work, the template edges must be smoothed with files and sandpaper.

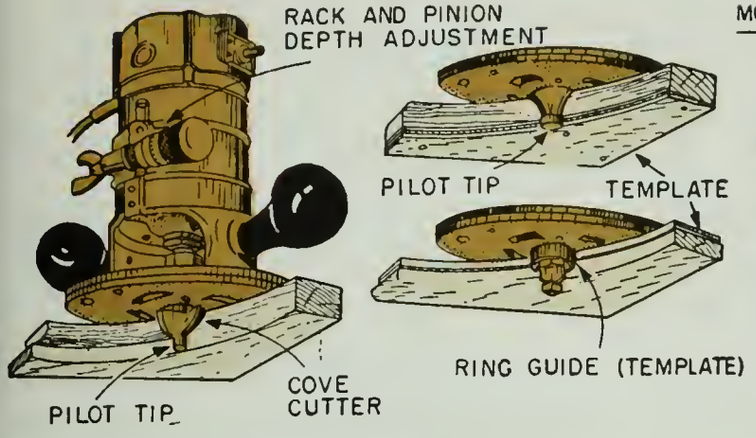
Hold the template in place on the work by driving brads into waste parts that will be cut away, or if this is not possible, by nailing cleats under the template where they will clasp the work. Place the router on the template with the guiding ring bearing against the template edge and trace around the edges of the template. If the design has large routed areas, use a small router bit to outline and then change to a larger bit to clean out the remaining waste wood.

Cutouts, such as grills, are similarly made, the bit being extended through the thickness of the work. Mount the work on a waste board to avoid marring the bench top with the bit tip.

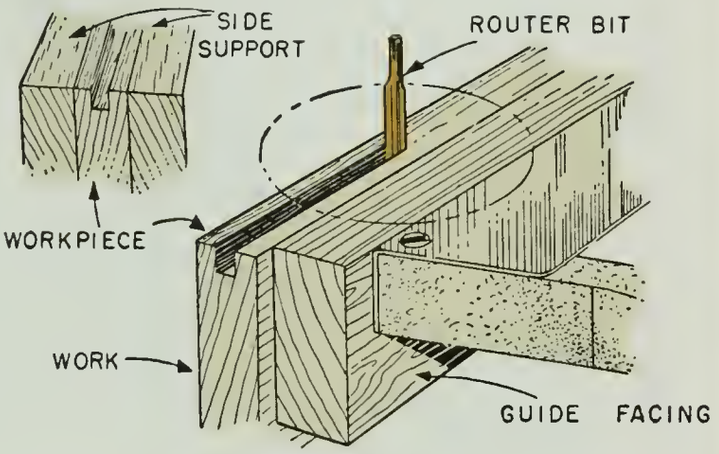
A box template is a convenience for production work. The piece is dropped or slid into the box and the template, hinged like a lid, is closed down over the work and clamped. Blanks of scrap wood cut out drop out of the way through the open bottom of the box.

Routers are excellent machines for quickly making carved wooden trays. First trace the design to the workpiece. Then, using the router freehand, work it into the pockets of the tray, using a router bit or shaping bit of suitable profile. Rough-cut to the design outline, and then go around again carefully trimming to the line. Depth is obtained by making two or more passes or cuts, lowering the bit each time. In some cases it is best to leave the outside edges of the tray unfinished for easier clamping, until the inside is finished. If you are making a tray with a large pocket, too wide to support the router base, fasten a piece of plywood to the router base to carry the machine.

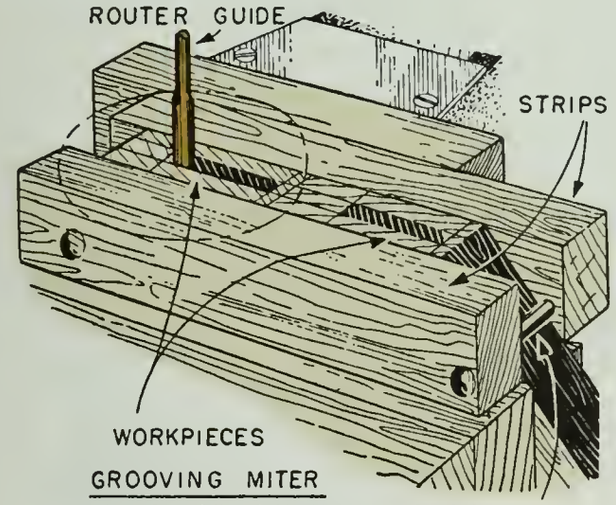
Because of the many cutter shapes available, the router can be used as a shaper for making decorative molded edges. Note that some of the cutters have a pilot or



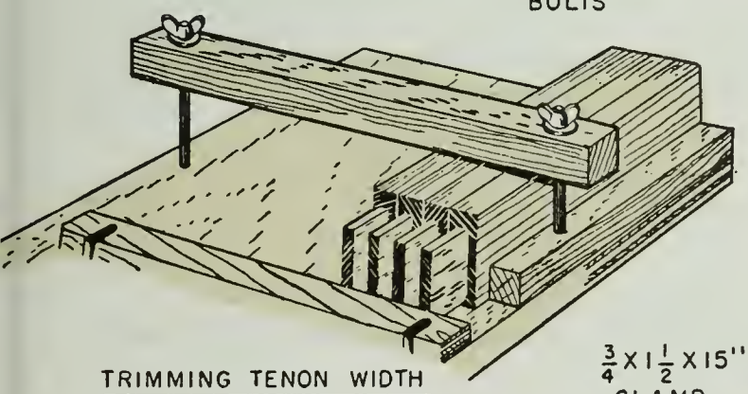
MOLDING CUTS WITH ROUTER



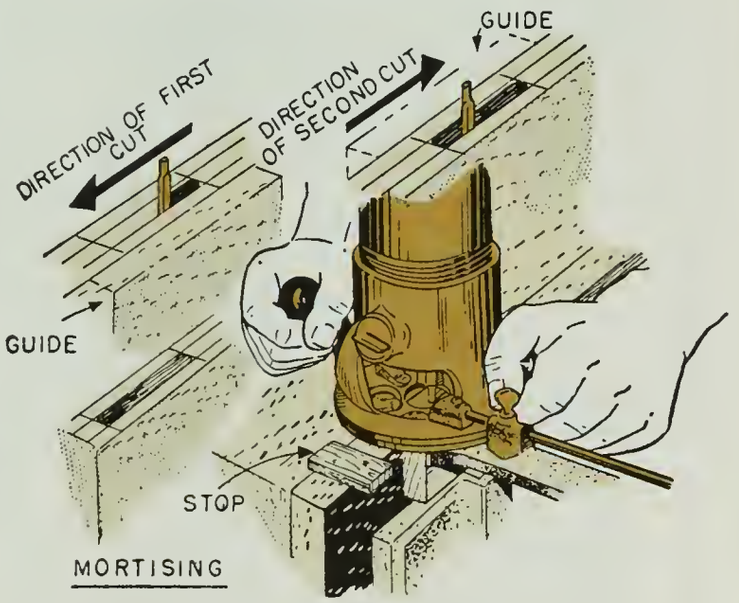
EDGE GROOVING



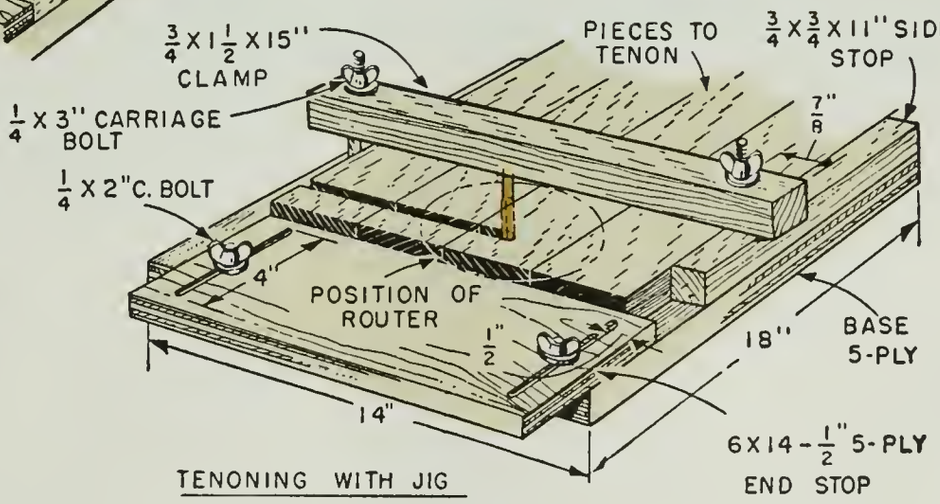
GROOVING MITER
JOINT FOR SPLINE



TRIMMING TENON WIDTH



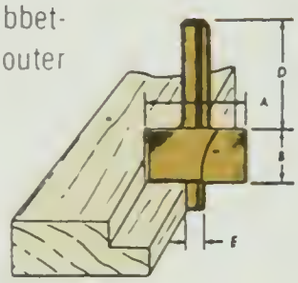
MORTISING



TENONING WITH JIG

RABBETING BITS — 1" SHANK LENGTH

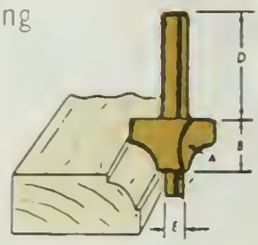
Pilot bit for making rabbeting cuts without use of router guide.



No.	A	B	D	Width Rabbet	E
High Speed Steel					
85 150	11/16	7/16	1	1/4	3/16
85 151	15/16	1/2	1	3/8	3/16
Carbide Tipped					
85 247	11/16	1/2	1	1/4	3/16
85 248	15/16	1/2	1	3/8	3/16

BEADING BITS — TWO FLUTES

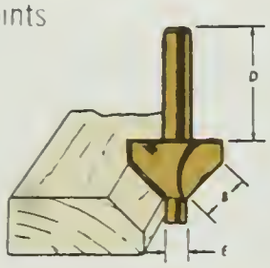
For decorative period furniture. Pilot guides router along edge of work



No.	A	B	D	E
High Speed Steel				
85 122	1/16	3/16	1	3/16
85 123	1/8	3/8	1	3/16
85 124	1/4	1/2	1	3/16
85 125	3/8	3/4	1	3/16
Carbide Tipped				
85 236	1/4	1/2	1	5/16
85 237	3/8	5/8	1	5/16

CHAMFERING BITS — TWO FLUTES

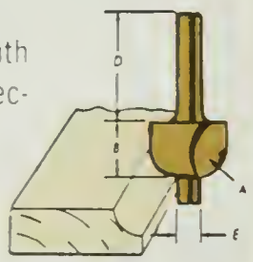
For making concealed joints and decorative edging.



No.	B	D	E
High Speed Steel			
85 131	1/2	1	3/16
Carbide Tipped			
85 239	1/2	1	5/16

COVE BITS — TWO FLUTES

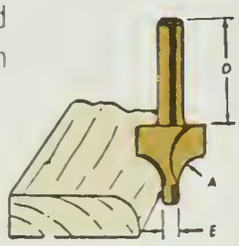
For drop leaf table joint (with rounding over bit) and decorative edging.

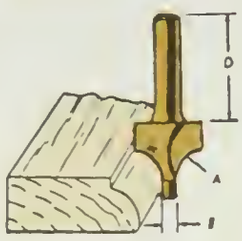


No.	A	B	D	E
High Speed-Steel				
85 126	3/16	3/8	1	3/16
85 127	1/4	1/2	1	3/16
85 128	3/8	5/8	1	3/16
85 129	1/2	3/4	1	3/16

ROUNDING OVER BITS — 2 FLUTES

For decorative edging and drop leaf table joints (with cove bit).

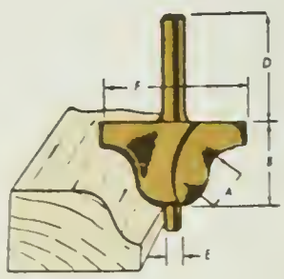




No.	A	D	E
High Speed Steel			
85 117	3/16	1	3/16
85 118	1/4	1	3/16
85 119	5/16	1	3/16
85 120	3/8	1	3/16
85 121	1/2	1	3/16
Carbide Tipped			
85 233	1/4	1	5/16
85 234	3/8	1	5/16
85 235	1/2	1	5/16

ROMAN OGEE BITS

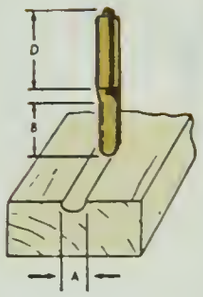
For decorative cuts.



No.	A	B	D	E	F
High Speed Steel					
85 161	5/32	1/2	1	3/16	15/16
85 162	1/4	3/4	1	3/16	1 3/16

VEINING BITS — SINGLE FLUTE

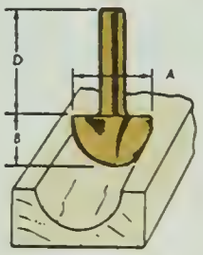
For decorative line work on flat surface.



No.	A	B	D
High Speed Steel			
85 105	1/8	5/16	1
85 106	3/16	7/16	1
85 107	7/32	7/16	1

CORE BOX BITS — TWO FLUTES

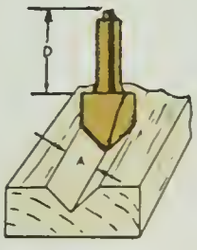
For fluting flat surfaces (mantels, facades).



No.	A	B	D
High Speed Steel			
85 108	1/4	1/4	1
85 109	5/16	1/4	1
85 110	3/8	1/4	1
85 111	7/16	1/4	1
85 112	1/2	11/32	1
85 113	9/16	3/8	1
85 114	5/8	3/8	1
85 115	11/16	1/16	1
85 116	3/4	15/32	1
Solid Carbide			
85 254	1/4	1/4	1
85 255	1/4	1/4	1 1/2

"V" GROOVING BITS

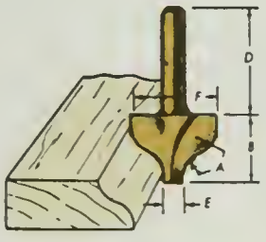
For lettering and sign work.



No.	A	D
High Speed Steel		
85 089	3/8	1
85 090	7/8	1
Carbide Tipped		
85 219	3/8	1
85 220	7/8	1

OGEE BITS

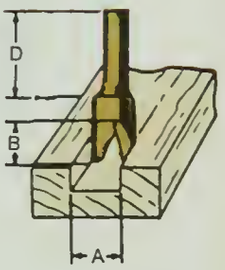
For decorative cuts.



No.	A	B	D	E	F
High Speed Steel					
85 163	3/16	5/8	1	3/16	13/16
85 164	9/32	29/32	1	3/16	1 3/16

BITS FOR HINGE MORTISING

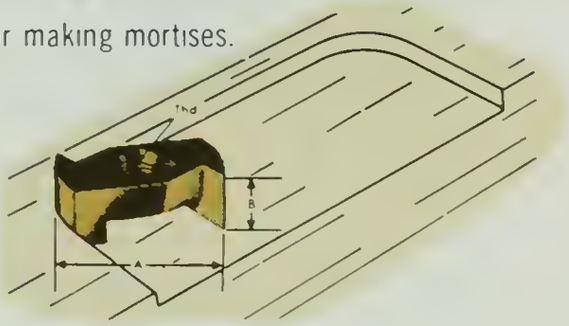
For making mortises when cut is started from edge of work.



No.	A	B	Shank D
High Speed Steel			
85 157	3/8	7/16	1 1/8
85 158	7/16	3/8	1 1/8
85 159	1/2	13/32	1 1/8
Carbide Tipped			
85 249	1/2	5/16	1 7/32

HINGE MORTISING BIT — 5/8" RADIUS

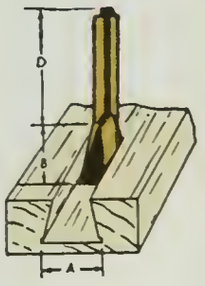
For making mortises.



No.	A	B	Thd.
High Speed Steel			
85 130	1 1/4	17/32	5/16 - 24
Carbide Tipped			
85 238	1 1/4	17/32	5/16 - 24

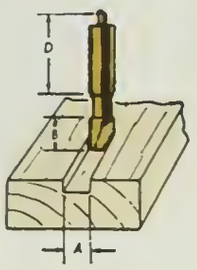
DOVETAIL BITS

For making dovetail joints.

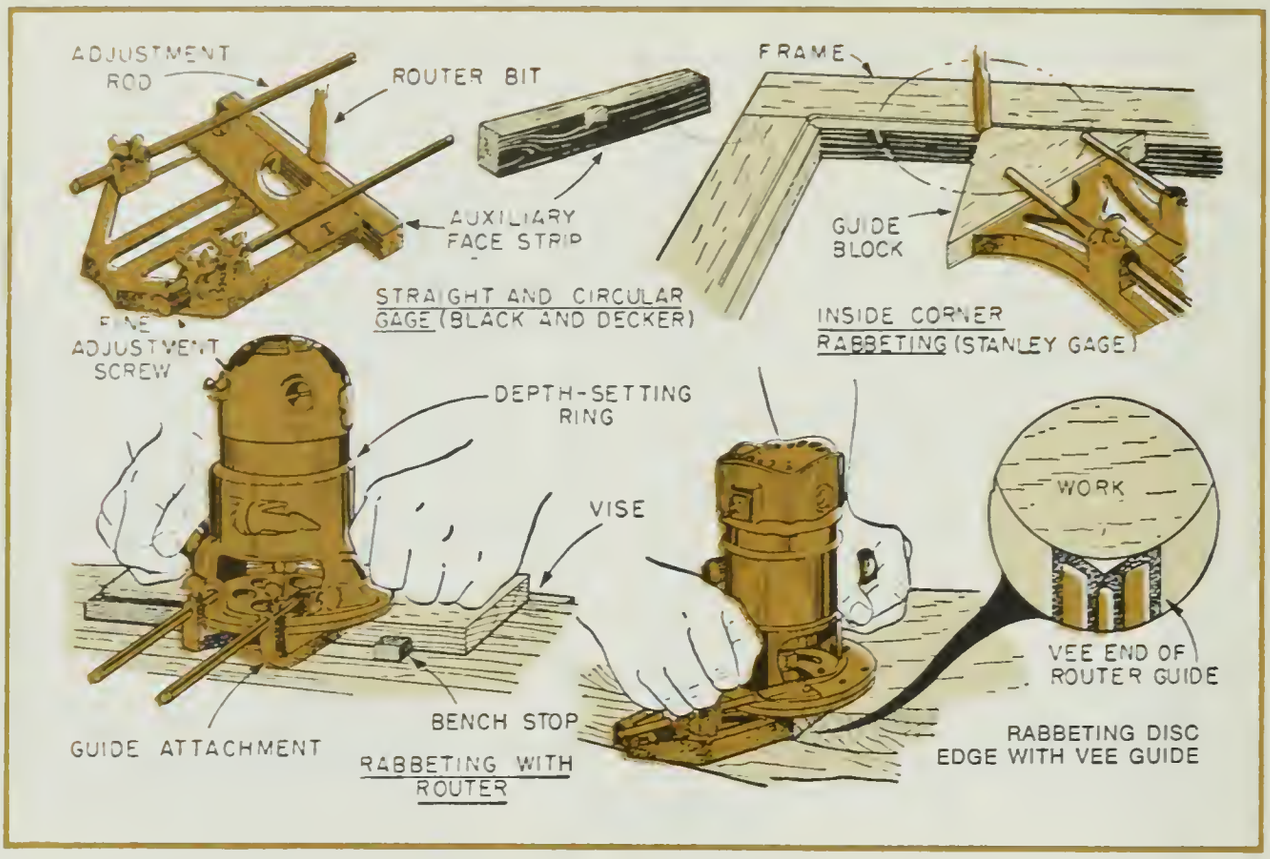


No.	A	B	D
High Speed Steel			
85 132	9/32	3/8	1 1/4
85 133	9/16	17/32	1 3/32
Carbide Tipped			
85 240	17/32	1/2	1 1/8

SOFT METAL CUTTING STRAIGHT BITS — SINGLE FLUTE



No.	A	B	D
Solid Carbide			
85 256	3/16	1/2	1
85 257	1/4	1/2	1



small cylindical tip projecting beyond the end of the cutter. When ⅛-inch or more of the lower edge of the workpiece can be left unshaped, it can be used as a guiding edge for the pilot to bear against. Start routing a molded edge at the left corner of the work and feed from left to right, the pilot sliding along the unshaped part of the edge. As the tip is only $\frac{3}{16}$-inch in diameter, it follows small curves readily; however, it will also reproduce any jogs or irregularities in the edge. For this reason, the edge must be well smoothed before shaping.

To shape the entire edge of the work, tack a template on the underside of the work for the pilot tip to bear against. It may be the same size or larger or smaller, depending on the profile and projection of the cutter. Pilotless bits, or shaper cutters, use a template above the work. As in rabbeting, shaping on straight and evenly curved edges can be done with the guide fixture too, either directly against the edge or with guide strips.

Edge grooving is a required operation for building panels and for joining boards edge to edge reinforced with a spine. This is identical to face grooving except that provision must be made for steadying the base of the router. This can be done by clamping a one-inch strip to each side of the workpiece flush with its upper edge, for the router base to slide upon, or by facing the guide fixture with a relatively wide strip which, held against the side of the work, will keep the base level during the cutting. The spline, usually ¼-inch plywood cut across the grain, matching the ¼-inch router bit used for grooving, is equal in width to the combined depth of the two grooves cut in the pieces to be joined.

Splines are excellent fasteners for mitered joints too. Use a setup for grooving similar to that shown in the drawing, where the two members of a joint are clamped between two strips bolted together. This forms a jig that can be used time and again. Center the bit accurately on the work. If the

edges of the joined pieces are to show in the finished assembly, it is better to make stopped grooves so that the spline ends will not show.

Mortise and tenon joints are easily made with the router. Lay out the mortise centering it on the thickness; and using a router bit a little narrower than the mortise, cut the mortise to length as in grooving. Then, with the router guide bearing against the other side of the work, make a second cut, which will trim the mortise to width and exactly center it. The rounded ends can be squared with a chisel, or the ends of the tenons can be rounded to fit.

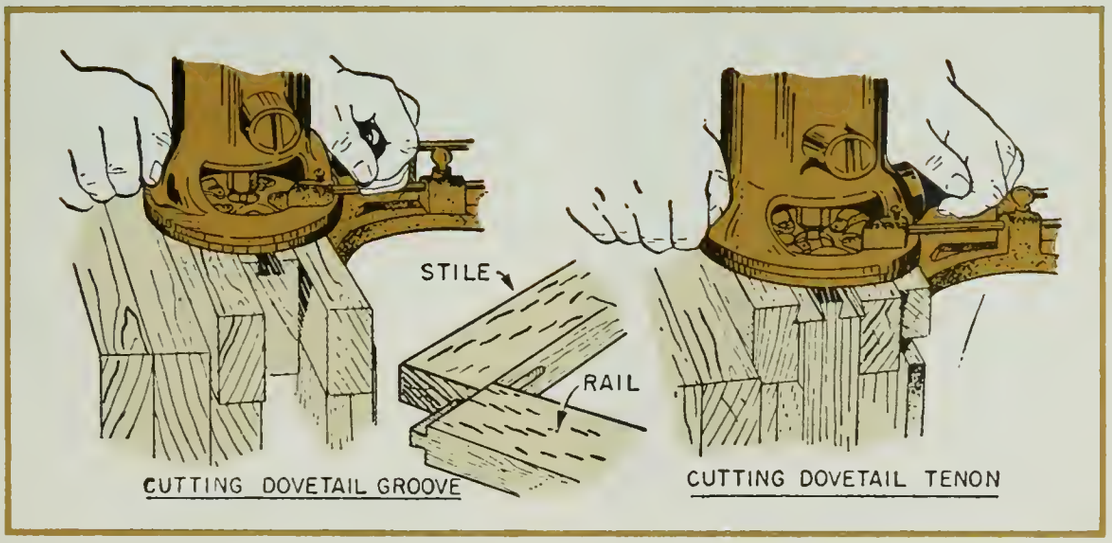
For making the tenons, set the router bit depth to make the tenon the same size as the mortise already made. Making tenons is a rabbeting operation, the shoulder being cut first and the waste trimmed away, working from the shouldered end to give maximum support for the router base. The tenoning jig detailed in the drawing provides an adjustable end stop, router base guide, and clamp for workpieces, and will handle one or more pieces at a time. After making cheek cuts, turn the pieces on edge, reclamp, and trim the tenons to width.

A tenoning jig is particularly useful for production work, because the end stop can be returned to a marked position for turning out duplicate parts quickly and accurately at a later date, or the jig can be left in a locked position to serve as a step in a production-line setup.

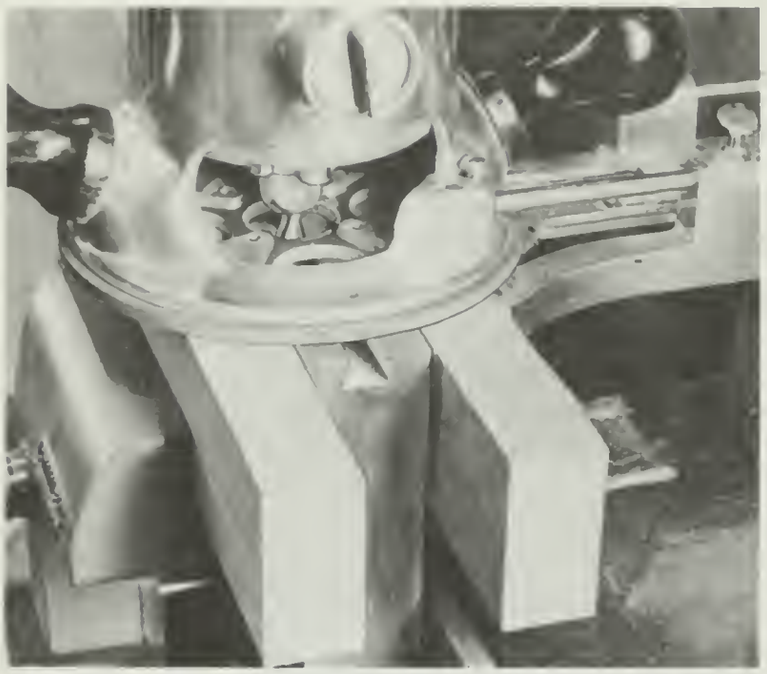
Dovetailed grooves have uses such as attaching a cleat to the end of a drawing board to lessen warping. Fastening, except at center, is not needed, the board being free to slide in the cleat as it shrinks or swells according to humidity. Use a dovetail cutter to make the groove. To make the tenon, cut two dovetail grooves, working partly in the side support strips, the part between the grooves forming the tenon. With accurate setup, the tenon is very slightly less in width than the mating groove, allowing for a push fit and a little glue room. This joint makes a strong connection between a rail and a stile, and can be left unglued for knock-down construction.

With a dovetailing jig, drawer sides, fronts, and backs can be perfectly made, the average joint taking about 30 seconds. Complete directions for setup and use are included with the fixture. The front is clamped horizontally, the side vertically, with an offset of one tail, so that both members are cut in one pass, the cutter threading in and out of the template fingers.

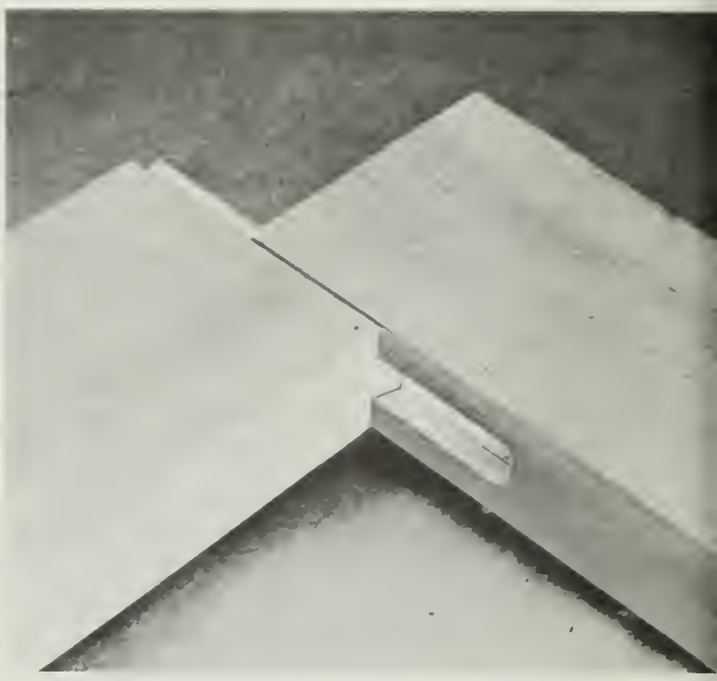
A router is invaluable to the home builder for mortising doors for hinges. Adjustable metal templates clamp to the door and



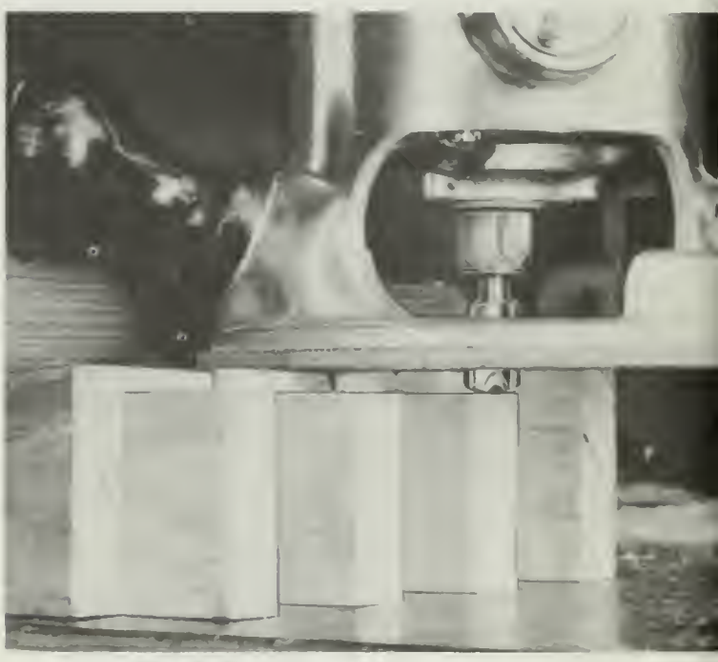
2208 *What You Can Do with a Portable Router*



▲ *Using a dovetail cutter. Note how the work is blocked into the vise and how the router guide is used to achieve a true cut.*



▲ *After the dovetail mortise was routed, the same cutter was used on each side of the tenon to make a matching dovetail.*

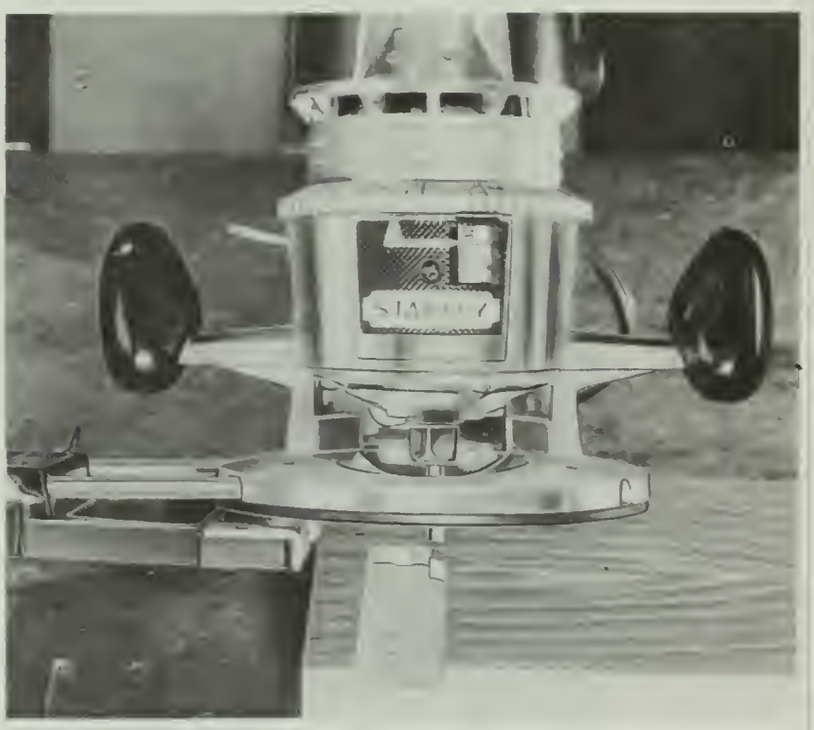


▲ *How several tenons can be routed as a unit.*

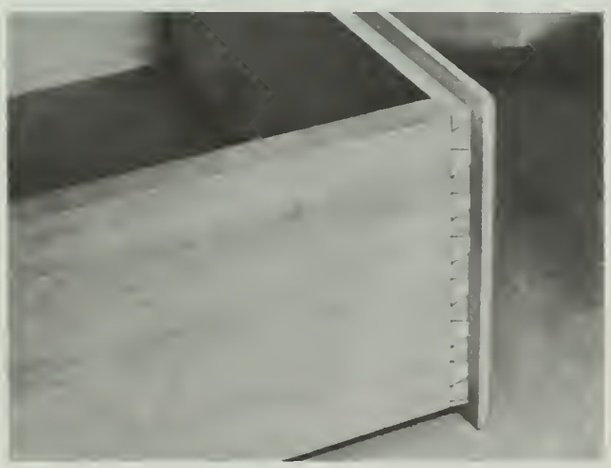
◀ *Routing a simple mortise. Block fixed to the router guide was used to keep the cut accurate.*

▲ *Cutting a cove. The cutter has a pilot to guide it along the edge. This cut is useful in making the joints for drop leaf tables.*

▼ *Make several passes with the router to cut a wide dado.*



▲ *A special jig is available to make dovetail joints of the type widely used in drawers.*



▲ *This dovetail joint was cut accurately and quickly with a special jig. Dovetail joints are used in drawers because they are extremely strong and are able to stand up to the repeated stresses caused by the opening and closing of the drawer.*

make perfect fitting of the hinge butts a matter of seconds. Rounded corners are left, which fit round-cornered hinges, or they can be trimmed with a cutter or a chisel to take regular hinges. M.E.

See also: CABINETS; INLAY WOODWORKING; POWER TOOLS; TOOL TECHNIQUES; WOODWORKING.

Build a Motorized Surfboard

You can make this fun boat in a weekend. Its safety features include a propeller tunnel and a deadman's throttle

THIS MOTORIZED SURFBOARD is a real fun boat designed to cover a lot of territory. A plexiglass window allows skin divers, or the merely curious, to clearly see what's on the bottom. You can use Buzy Bee for fishing, shell collecting, or simply puttering around in the summer sun. There's space aboard for small equipment, such as a spear gun or gaff, or even a small anchor if you want to moor away from shore. And, perhaps best of all, you can build it yourself in one weekend.

The board will idle along at barely more than a standstill, or step along at its top speed of 8 mph—which is pretty exhilarating when you're lying there just a few inches above the water. You steer with your feet, or by shifting your weight from side to side, as you would on a sled.

The propeller is mounted well forward, where it is nearly impossible to reach, and it is surrounded by an aluminum shield as an added safety measure. A "dead man's" throttle is used—if you release your grip on it, the engine stops. If you should happen to fall off the boat, it won't run away from you, and the propeller won't be turning when you climb back aboard.

Foamed-in-place flotation makes it possible for board to support 350 pounds, so even if it is swamped or damaged, it will still carry the weight of engine and operator. All in all, it is a safe and sturdy package that will withstand a lot of hard use.

The engine is a small, 3½-hp. Clinton Super 415 fitted with a heavier flywheel to make it easier to start. This motor has a vertical shaft, which is connected to the gear and propeller assembly from an old outboard motor. You can get a lower unit from an obsolete 3- to 5-hp. outboard for next to nothing. A commercial unit called a Jaw Coupling makes this hookup a cinch.

The finished boat weighs just under 80 pounds, so it isn't too difficult for one adult, or a couple of children to hoist it in and out of the family station wagon. Grab handles on the bow and stern add to the ease of handling.

To build the board, it is necessary to set up a simple building jig. Set up two 8-foot lengths of 2 x 4-inch (or heavier) timbers on sawhorses, as shown. The timbers should be spaced about 18 inches apart. Set up 2 x 4-inch cross beams at each frame location, as illustrated. Make sure these cross members are exactly parallel to each other, and at right angles to the long timbers.

Next step is to make up the ribs. You can make patterns, using builders' paper,

running lights: see navigation
rustic bar: see bars
rust-outs: see repairs, automobile
rust removal: see spot removal

or draw the lines and dimensions directly on the wood. As there are no curves to worry about, this method is fastest.

Note that Rib #1 is a solid piece of ¾-inch redwood or cedar. The other ribs are made up with cedar planks backed by 3/16-inch plywood. Rip saw the ¾ x 12-inch x 12-foot timber into 3-inch wide planks; this will provide your keel and rib members. Leave the side rib members about 6 inches longer than necessary.

Glue mating surfaces of plywood and rib members, and fasten with ¾-inch #16 bronze boat nails through the plywood into the wood. Space the nails about 2½ inches apart.

Bevel the bottom of Rib #1 to the proper angle to accept the keel. If you have a jointer, it is easy to do this, and also to bevel the surfaces where bottom and side planks attach.

Mount each rib on its cross beam on the jig, nailing the extra length protruding at each to the beam to hold the rib securely in place. Be sure that each rib is at a 90° angle to the keel line, and exactly perpendicular to the jig. The ribs will be upside down, of course. Note that the sheer line is absolutely straight, so take this into account as you align the ribs.

Nail or clamp a pair of angled uprights to the two long timbers of the jig. These uprights will position the first rib, so make sure that they are the same distance from the frame and angled exactly as shown. Clamp Rib #1 to the uprights.

The keel is installed next. To make it take the curve at the bow without putting too much strain on the ribs, cut two slots in the wood, each about 10-inch deep. The photograph showing the keel clamped to Rib #1 illustrates how the cuts were made. A band saw is best for this, if one is available.

Glue mating surfaces of ribs and keel, and run glue into the saw cuts at the bow. Then fasten the keel to each rib with two 1½-inch #8 flat head brass wood screws. Countersink for the screw heads enough to allow for beveling the keel so it fairs with the rib bottoms.

The planking must lie absolutely flat against all keel and rib surfaces, so this is an important job, and must be done carefully. Check with a flexible wood batten, or a long steel ruler, to make sure that surfaces are fair. Of course, if you have an electric plane, the work will be much easier.

Now install the two side beams between the third and fourth ribs. Bevel the bottom edges so the bottom planking will fit flush against them. Also, the keel between these two ribs is backed on the inside by a length of ¾ x 3-inch stock to provide additional support for the plexiglass windows to be installed here. Be sure to use glue on all mating surfaces. Use 1½-inch #8 flat head brass screws to attach the side pieces and keel backup plank.

Make up the motor box between the second and third ribs, using ¾ x 3-inch stock for the stringers between the ribs, and the uprights at each end. Glue and nail the plywood box sides in place.

The sides are made up of ½ x 5½-inch redwood or cedar. Glue and clamp them in place at each rib, then fasten with three 1½-inch #8 flat head screws at each rib

Steer the little motorized surfboard with your feet and by shifting of weight. It makes a dandy platform for skin divers.

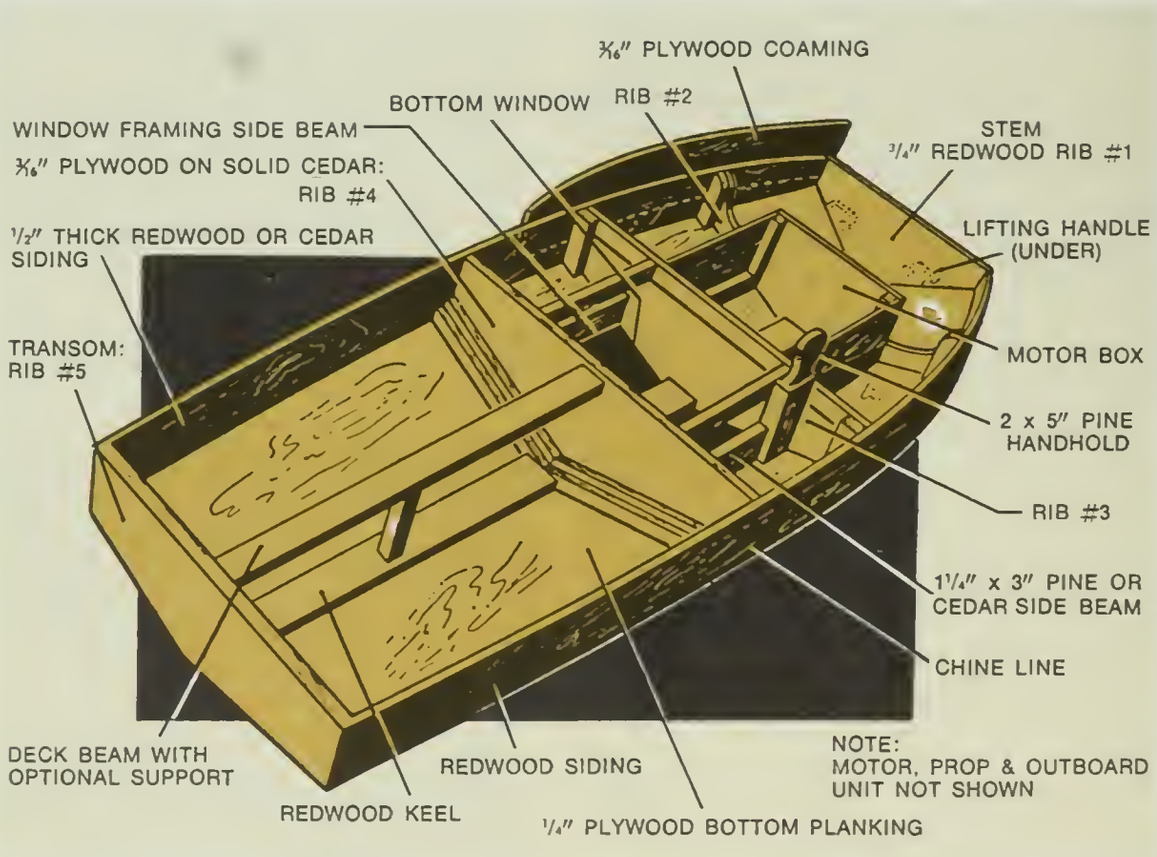
—one at the top, one at the bottom, and one in the middle. Trim the panels to the proper shape, and bevel the bottom edges so the bottom planking will lie flush against them for the entire length of the boat.

Now the bottom panels of 3/16-inch exterior grade or marine grade plywood can be applied. Be sure to cut out a rectangle on each for the plexiglass panels. Leave about ½-inch space on ribs, sides and keel to provide the support for the plexiglass. This is shown clearly in the photos. Glue the bottom panels in place, and fasten with ¾-inch bronze nails, spaced about 2 inches apart. Be sure there's plenty of glue between the bottom panels and the sides.

At this point the boat can be fiberglassed, if desired. It adds to strength and durability, and is worth the slight additional cost for the materials. It's easy, too, and you can mix color with the resin to eliminate the need for painting. Use a roller to apply the mixed resin to the wood, then apply the cloth. You can staple it in place, and it's a good idea to butt-join adjacent panels of glass if you don't want the slight hump formed by overlaps. The glass should all be in place before the first coat of resin starts to cure, and a second coat of resin should be worked into the glass immediately.

Make sure the cloth is wet-out completely, and there are no air bubbles or resin voids that will cause blistering, cracking or peeling later. When this cures, a final thin coat of resin can be applied with a squeegee. This trick will give you a very slick, professional finish.

When this has cured, remove the boat from the jig and turn it over. Carefully saw off all rib projections flush with the sides. Next cut and install the deck beam between ribs 4 and 5 (and install the beam support if you don't plan to use foamed-in-place flotation). Then glue and screw in place the deck beams over the glass window open-



▲ *Building jig of 2x4's or heavier timber is set up on sawhorses. Keel is clamped to ribs prior to being screw-fastened. Rib #1 is clamped on jig. Scarf cuts enable the keel to bend easily.*

▼ *Keel has been beveled to match rib angle and side planks have been installed. Edges of side are checked to make sure plywood bottom will fit flush. Note details of window, motor boxes.*

◄ *Here, bottom planking has been installed. Use only exterior or marine grade. A 1/2-inch ledge is left on ribs and viewing box sides to accept plexiglass.*

► *Final coat of pigmented resin is squeezed onto fiberglass. Glass that covers window openings here will be trimmed away while the resin starts its cure.*

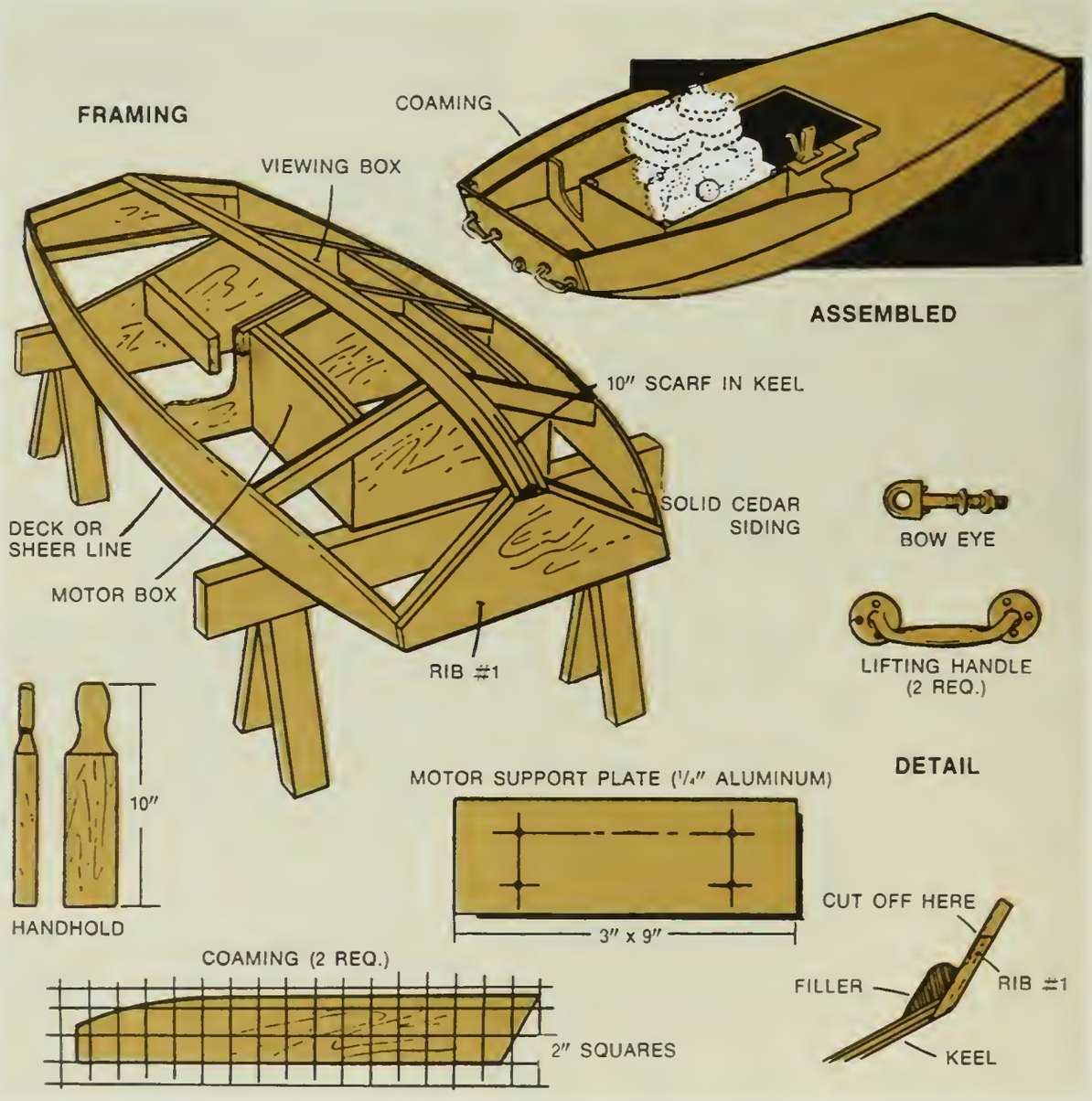
ing, and shape the right hand-hold, and fasten it in place as shown in the photographs.

For strength and positive flotation, use a foamed-in-place flotation kit. It takes two 1 quart kits to provide enough foam; mix and use just one at a time. It only takes a few minutes for the mixture to foam up and cure, and then you can cut it off flush with the sides and deck beam with a hand saw. Be sure all your resin and foam applicaions are done in a well-ventilated space, as the fumes can be toxic.

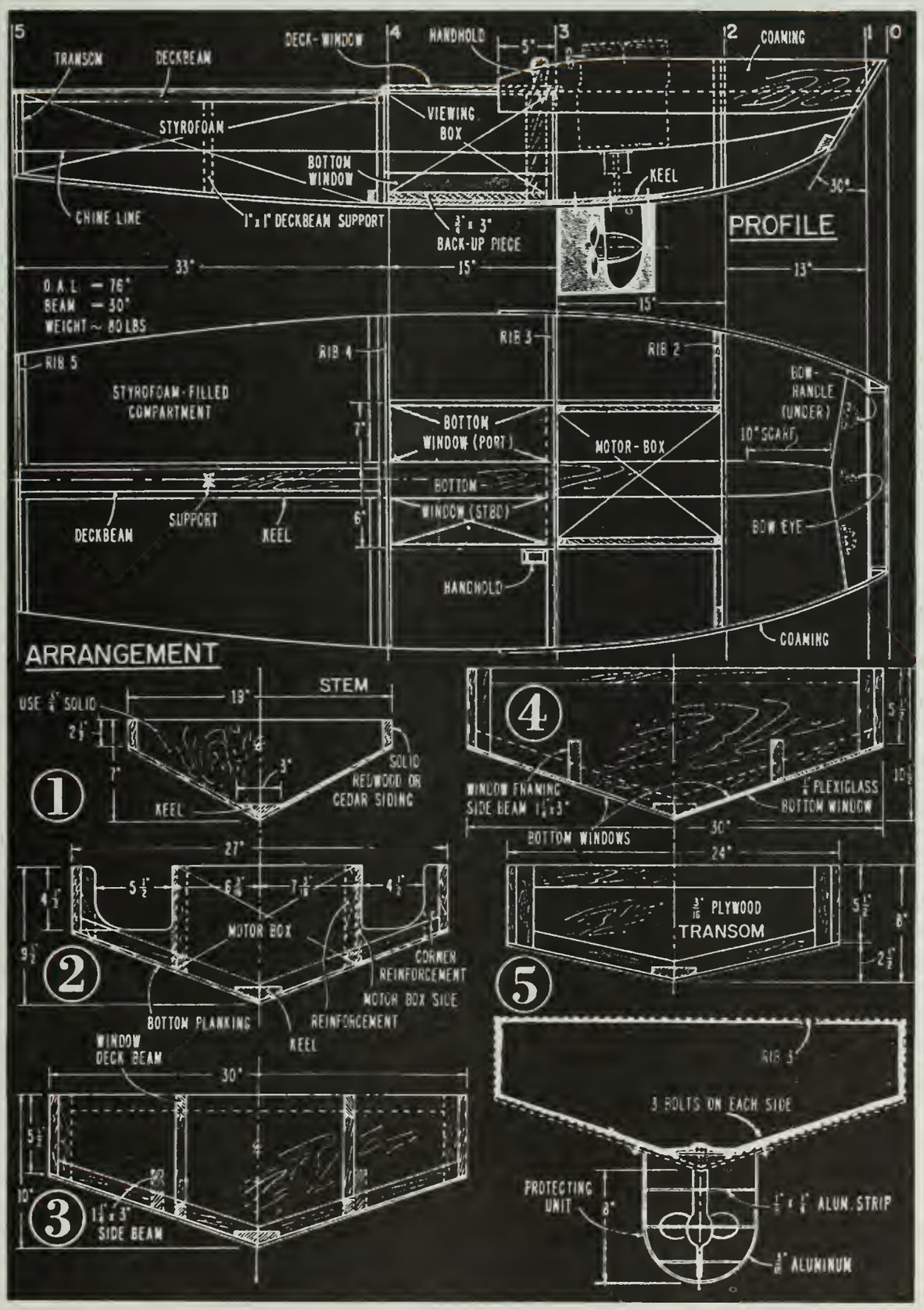
Drill through the keel for the shaft of your outboard lower unit. Exact location of the hole will depend on the shape of the unit, but it should be at the center—or just aft of center—of the distance between the second and third ribs.

Turn the craft back over, and mount the lower unit in place. It may be necessary to cut some shims to go between it and the keel in order to get the shaft exactly perpendicular, and to get a perfect seal between the unit and the hull. Drill the bolt holes for the unit, and bolt it securely in place. Use a good marine sealant as a bedding compound to keep water out of the gear case.

Make up the aluminum safety guard for



Build a Motorized Surfboard 2215



Foamed-in-place flotation is trimmed with a hand saw. It takes only minutes for mixture to foam up and cure. Proper ventilation is important; its fumes can be toxic. Note handgrip behind #3 rib.

Plexiglass panels are screwed into place on the bottom of boat. It is well to leave paper backing in place until everything is finished in order to guard against scratching plastic surface.

Flat plates on ends of the motor mounts wedge against the sides of the motor box. The assembly is clamped in position and shifted until the desired alignment is obtained. Then holes are drilled through box sides and end plates and mounts bolted in place. Mount motor high as possible to allow for proper air circulation.

the propeller. This is simply an aluminum tunnel bolted over the lower unit, as illustrated. The aluminum cross strips help it hold its shape. Be sure the aluminum you use is an alloy designed for marine use. Aircraft and household aluminum will corrode rapidly in marine service.

As this is the last time you will be working on the boat upside down, you can install the plexiglass viewing panels. They can be cut to exact size with a table saw, or even a jointer planer. About every 1½-inch, drill and countersink holes for ¾-inch #7 flat head brass scews.

Note that the plexiglass will be thicker than the bottom planking, so it is necessary to sand the edges until they are flush with the surrounding wood.

Remove the paper backing from the inside of each panel, and install them, using a marine sealer under the glass. Fasten with the screws for which the holes were drilled. After the excess sealer is removed, the outside protective paper can be removed—although it's best to wait until everything else is done to minimize the chance of marring the plexiglass.

With the boat right side up, you can install the motor. It may be necessary to have the lower unit shaft cut to the desired length. It is coupled to the motor with Jaw Coupling, one half of which is fastened to the lower unit shaft, the other half is fastened to the motor drive shaft. If the shafts are of different diameter, you simply get the proper size for each, as the coupling faces are always the same size.

The motor mounts can be made up of angle aluminum, with flat plates welded to the ends. The mounts should be just wide enough to fit between the sides of the motor box. Clamp the motor assembly in place, shifting it slightly until proper alignment is obtained, then drill through the motor box sides and the mount end plates, and bolt the mounts to the motor box.

It is a good idea to mount the motor as high as possible so it can get plenty of air. You may have to install an angle pipe to get the exhaust to point in the right direction—away from the boat to either side. This is no problem, as all small motors use a common size exhaust outlet pipe, and the angle pipes can be obtained from any plumbing supply house.

Now the decking can be glued and nailed in place, and it can be made in two sections from scrap plywood. You can fiberglass over the deck after it has been trimmed flush with the sides, but omit the final squeegee coat of resin. The rough texture remaining is better for decking.

The coaming panels are added next, across the bow and on each side. The coaming acts as a splash board to keep the motor dry in rough water.

A "dead man's" throttle is a must, as noted earlier. The little Clinton motor is set so the ignition is grounded out, cutting off the spark, when the throttle is completely closed (typical of many lawn mower-type engines). When you let go of the throttle, the engine stops!

To complete, install lifting handles at bow and stern, and a bow eye. H.K.

See also: BOAT BUILDING; BOAT BUILDING PROJECTS; RACING BOAT; RAFT; SURFBOARD; WOOD BENDING.

WHERE TO FIND IT

The power source for Buzy Bee consists of a 3½-hp Clinton Super 415 with heavy flywheel and a used outboard lower unit (from 3- to 5-hp motor).

The "dead man's" throttle, called a deck throttle, is available from Keller, 18340 Ashworth Ave., Seattle, Wash. 98133.

MATERIALS LIST

Quantity	Size and Description	Purpose
2	3/8" 4'x8' marine or exterior grade plywood	planking, motor box and rib gussets
1	1/2" 6"x14' redwood or cedar	sides
1	3/4" 12"x12' redwood or cedar	keel and framing
1	1 1/4" 5"x36" redwood or cedar	glass box sides and hand hold
2	1/4" 10"x16" plexiglass	viewing window
2	Foam-It mix kits	flotation
as needed	#16 3/4" bronze boat nails	
as needed	#7 3/4" flat head brass wood screws	
as needed	#8 1 1/2" flat head brass wood screws	

NOTE: Also need plastic resin glue, fiberglass cloth, fiberglass resin and color, boat sealer, paint, lifting handles, safety throttle and power source.

Build a Sailing Dinghy

This pram is light enough for car-top travel, but strong enough to carry a small outboard motor

EIGHT BALL IS A SMALL but practical package that can offer a lot of fun and usefulness. It's a row boat, a ship-to-shore dinghy, a sailing dinghy, or a mini-outboard. It's light enough to be carried on a car top or the deck of a larger boat, and easy to haul up onto the beach after a day of use.

Overall length is 7 feet 10 inches so that standard 4 x 8-foot plywood panels can be used in its construction. Special mid-ship knees eliminate the need for center frames, and the only thing needed in the way of a building jig is an 8-foot length 2 x 4.

Trim the forward end of the long 2 x 4 to fit inside the bow box knee, and bevel both ends to the proper angle for the bow and transom panels. Set the 2 x 4 up on two supports, as shown, and the building jig is ready.

Note that the transom, centerboard/seat, and bow units are cut out and made up as complete assemblies before they are positioned on the jig. The bow and transom knees are open box units with ½-inch plywood sides glued and screwed to ¾-inch stock hardwood spacers. These are extremely strong, yet light and simple to build.

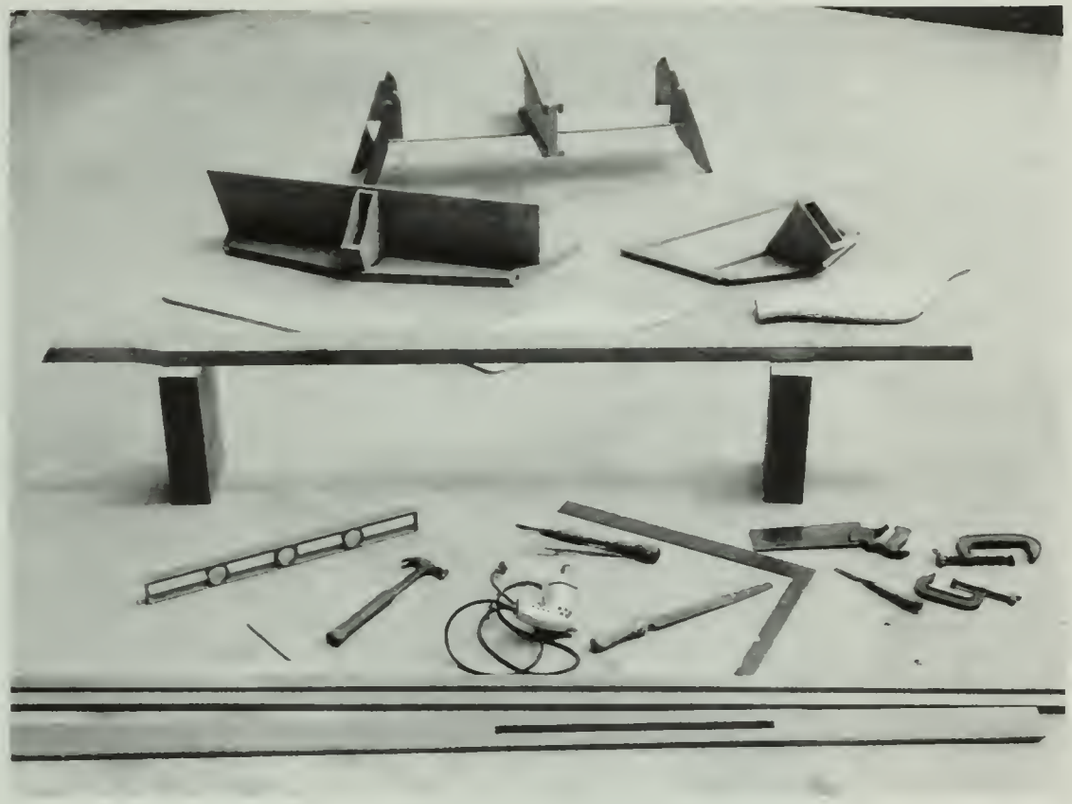
Knees of ¾-inch hardwood stock at each end of the center seat do the work of frames in setting the angle for the boat's side panels. When the chines and bottom panels are installed, there's no play at all in the hull.

Clamp the transom, centerboard, and bow assemblies to the jig, or temporarily nail them in place. Be sure the centerboard unit is placed exactly as illustrated. The transom assembly rests on top of the jig; the bow box knee must be slipped over the forward end of the jig.

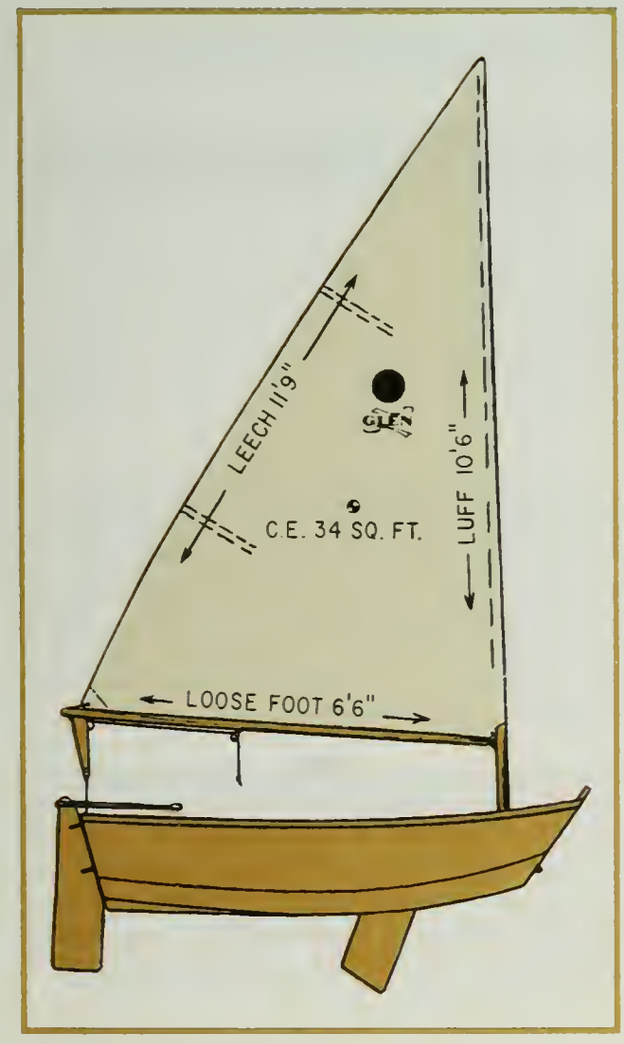
The keel is then glued and screwed to the transom knee, the centerboard case, and the bow knee. Screws must be well countersunk because the surface of the keel member must be beveled and faired so the bottom planking will lie flush against it. Spring the two hardwood chines into place, and fasten with screws to the transom, seat knees, and bow. Fasten both at the transom first, then the center seat, and finally the bow in order to eliminate too much stress on one side that could distort the hull.

Build a Sailing Dinghy 2219

Building jig is a 2 x 4 set on uprights. In foreground: keel (with centerboard slot cut) chines, needed tools. Behind jig: rudder, centerboard, forward seat.



Two sheets of 4 x 8-foot exterior type plywood will suffice for planking and much of interior structure. No complicated jigs or fixtures are required.



Centerboard and transom assemblies are nailed temporarily to jig. Note: both seats rest right on jig. Hardwood knees at each end of centerboard seat eliminate need for full frames.

Note how box knee is slipped over trimmed end of 2 x 4 jig member, also temporary crosspiece below the centerboard.

MATERIALS LIST

Quantity	Size and Description	Purpose
1	3/4" 2"x16' mahogany or spruce	frame, centerboard and seat brace spacers
1	3/4" 1"x9' mahogany or spruce	seat brace and filler strips for centerboard
1	3/4" 2 3/4"x6' mahogany or spruce	deck beam
1	3/4" 1 1/2"x2' mahogany or spruce	seat brace
1	3/4" 3"x7' mahogany or spruce	keel
2	5/8" 1 3/4"x8' mahogany or spruce	chine logs
2	3/4" 1 1/4"x8' mahogany or spruce	sheer clamps
2	1/4" 4'x8' exterior AA plywood	planking
1	1/2" 4'x8' exterior AA plywood	transom
1	2" 2"x13' Sitka spruce	mast
1	3/4" 1 3/4"x7' Sitka spruce	boom
as needed	#8 1 1/2" flat head wood screws	
as needed	3/4" annular thread bronze nails	
as needed	1" annular thread bronze nails	
as needed	1 1/4" annular thread bronze nails	

NOTE: Also need hot dipped galvanized, brass or bronze fastenings, sail and urea resin glue.

Fair the bottom edges of the chines so bottom planking will lie flush.

Cut the two side panels from ¼-inch exterior marine grade plywood, leaving a little extra material for trimming along the bottom and ends. Clamp a brace between the seat knees, below the centerboard. Now apply glue to the edges of frame members, and fasten the panels in place with screws or ridge boat nails spaced about 2 inches apart. Trim edges flush with the ends and chines.

Next cut out and install the two bottom panels. Again sides and ends should be left slightly oversize, and trimmed after the panels are glued and fastened in place.

Now remove the hull from the jig and turn it upright for installation of rub rails, forward seat, and mast step. You may want to paint the exterior first, and then install rub rails of a contrasting color, or finished bright (varnished).

SPECIFICATIONS

Length overall	7'10"
Beam	4'4"
Maximum depth	1'6"
Sail area	34 sq. ft.
Hull weight	75 lbs.

Install the necessary hardware on the hull, rudder, and centerboard. Make up the boom and mast. While it is possible to make up your own sail, best results will be obtained if you leave this to a professional.

See also: BOAT BUILDING; BOAT BUILDING PROJECTS; LAND SAILER; TRAINING BOAT.

WHERE TO FIND IT

Sail, hardware kits and plans are available from Glen L. Marine Designs, 9152 E. Rosecrans, Bellflower, Cal. 90706. Write to them for details.

This Lightweight Pram Is Easy to Build

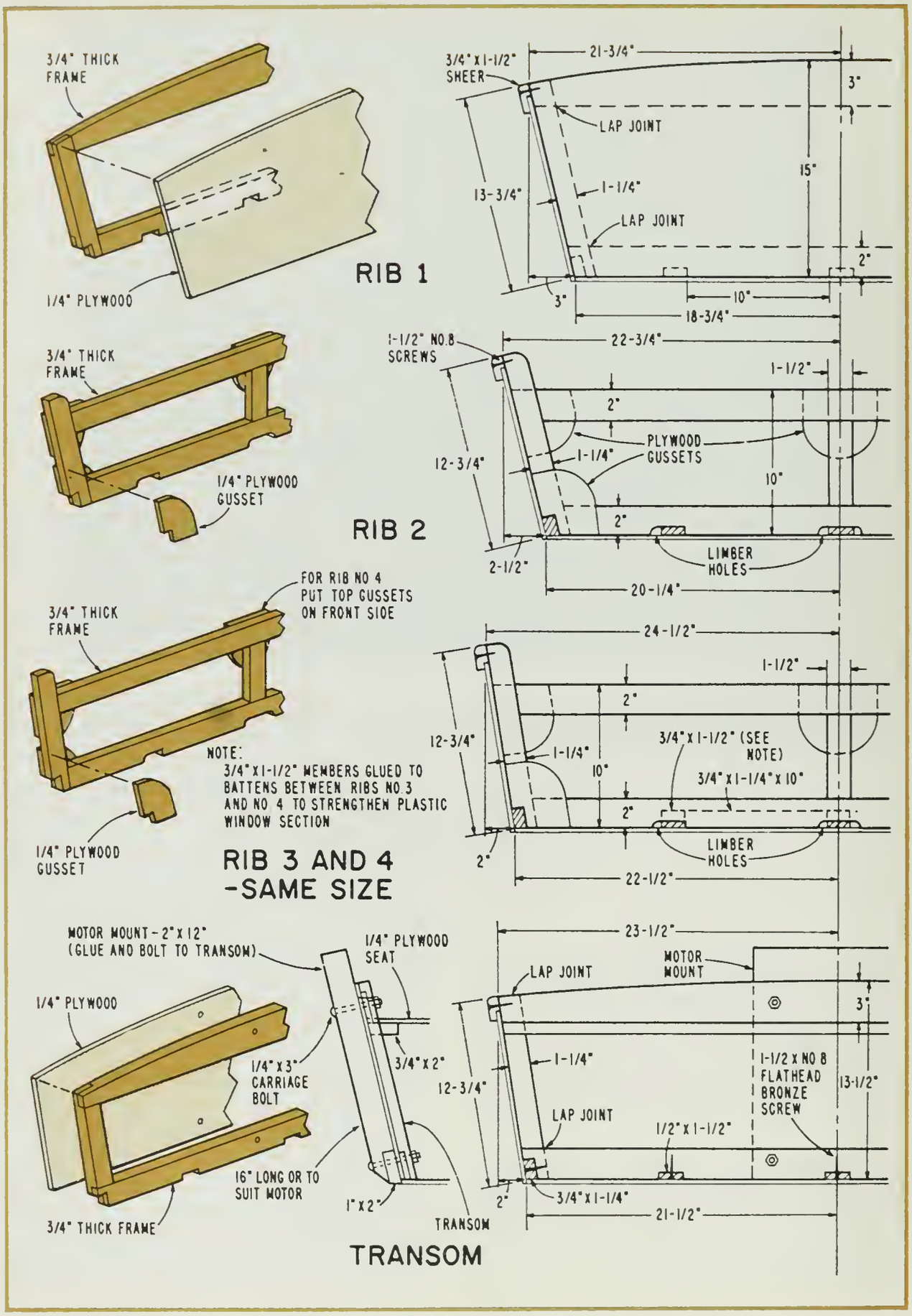
This small boat can be used as a fishing skiff or as a tender for a larger boat

THIS LIGHTWEIGHT PRAM is designed for oar power, or a modest outboard of not more than three horsepower. The boat is an ideal tender for a cruiser or auxiliary; it's a good fishing skiff, too, with the plexiglass panel in the bottom that let's you spot the fish.

Simple construction uses marine or exterior grade plywood over solid frame members. If you use the cheaper exterior grade plywood, the money saved will cover the cost of fiberglassing the bottom.

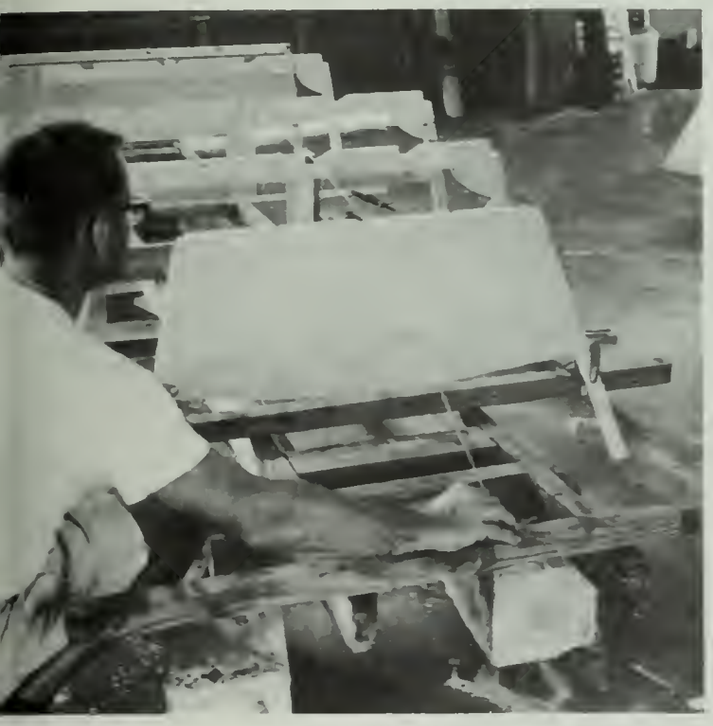
Start by setting up a jig, which is nothing more than two parallel 2 x 2-inch members cross braced at each frame station. This jig can be set up right on a level floor, but raising it on concrete blocks will provide a more comfortable working height.

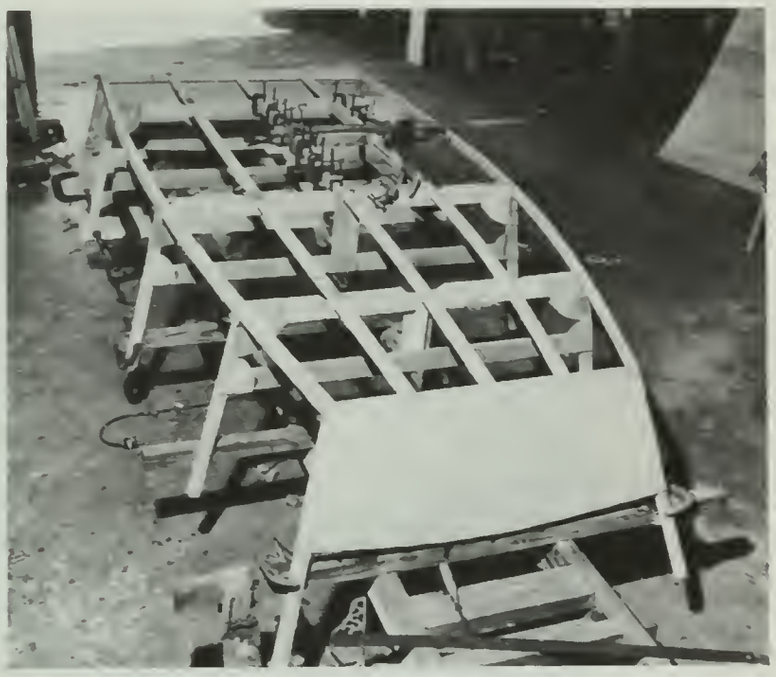
As can be seen in the detailed drawing the jig crosspieces extend well out past the parallel members, and that frame side pieces are left long enough to be clamped to these crosspieces. At the bow and transom stations, the crosspieces must be angled, at 30° and 14° respectively, to the perpendicular in order to provide proper align-


3/4" THICK FRAME
1/4" PLYWOOD
RIB 1
3/4" x 1-1/2" SHEER
21-3/4"
3"
LAP JOINT
15"
13-3/4"
1-1/4"
LAP JOINT
2"
3"
10"
18-3/4"
3/4" THICK FRAME
1/4" PLYWOOD GUSSET
RIB 2
1-1/2" NO.8 SCREWS
22-3/4"
1-1/2"
2"
PLYWOOD GUSSETS
12-3/4"
1-1/4"
10"
2"
2-1/2"
LIMBER HOLES
20-1/4"
FOR RIB NO 4 PUT TOP GUSSETS ON FRONT SIDE
3/4" THICK FRAME
NOTE:
3/4" x 1-1/2" MEMBERS GLUED TO BATTENS BETWEEN RIBS NO.3 AND NO 4 TO STRENGTHEN PLASTIC WINDOW SECTION
1/4" PLYWOOD GUSSET
RIB 3 AND 4 -SAME SIZE
24-1/2"
1-1/2"
2"
12-3/4"
1-1/4"
3/4" x 1-1/2" (SEE NOTE)
10"
3/4" x 1-1/4" x 10"
2"
2"
LIMBER HOLES
22-1/2"
MOTOR MOUNT - 2" x 12" (GLUE AND BOLT TO TRANSOM)
1/4" PLYWOOD SEAT
1/4" PLYWOOD
1/4" x 3" CARRIAGE BOLT
3/4" x 2"
16" LONG OR TO SUIT MOTOR
1" x 2"
3/4" THICK FRAME
TRANSOM
23-1/2"
LAP JOINT
MOTOR MOUNT
3"
1-1/4"
12-3/4"
1-1/2 x NO 8 FLATHEAD BRONZE SCREW
13-1/2"
LAP JOINT
1/2" x 1-1/2"
2"
3/4" x 1-1/4"
21-1/2"
TRANSOM

ment of the bow and transom. Or you can just cut the angles in the crosspieces at the points where the frame extensions will be clamped.

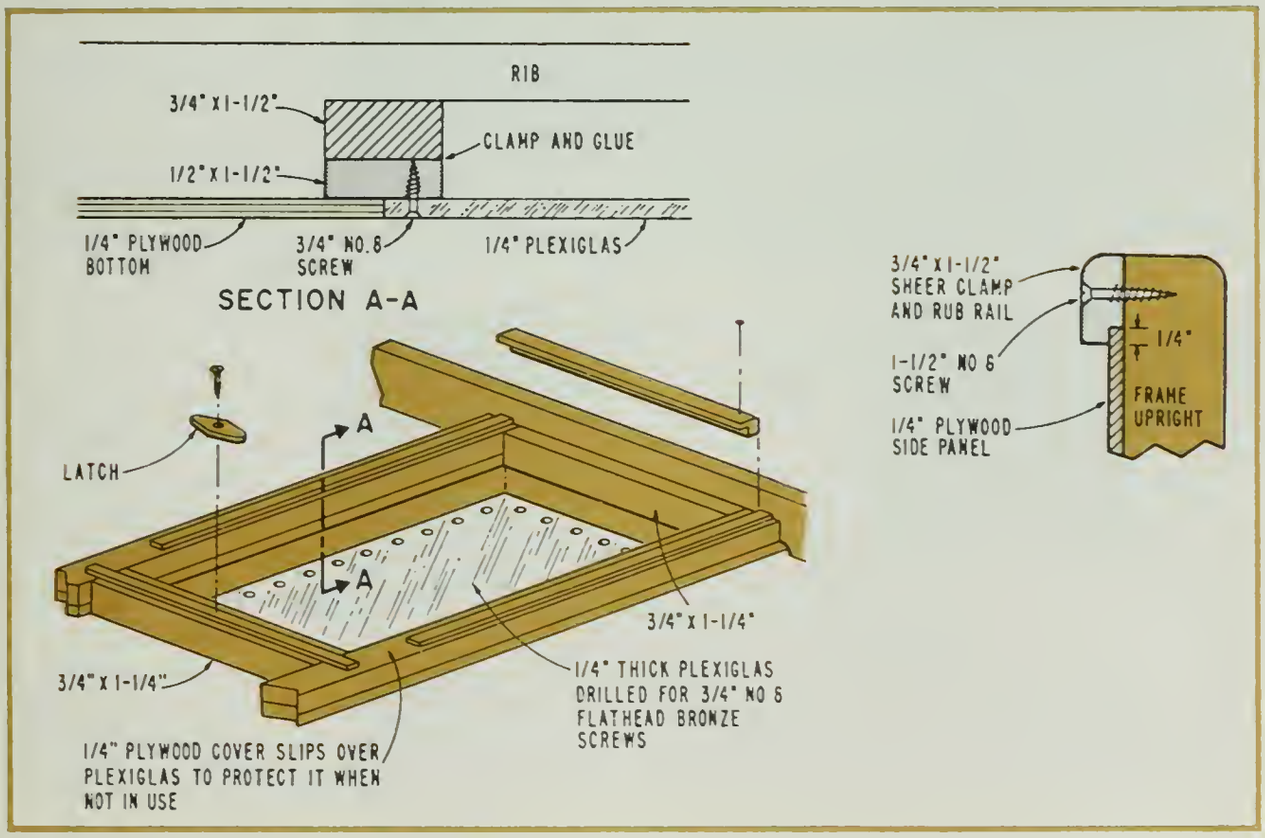
You can use ¾-inch white cedar stock

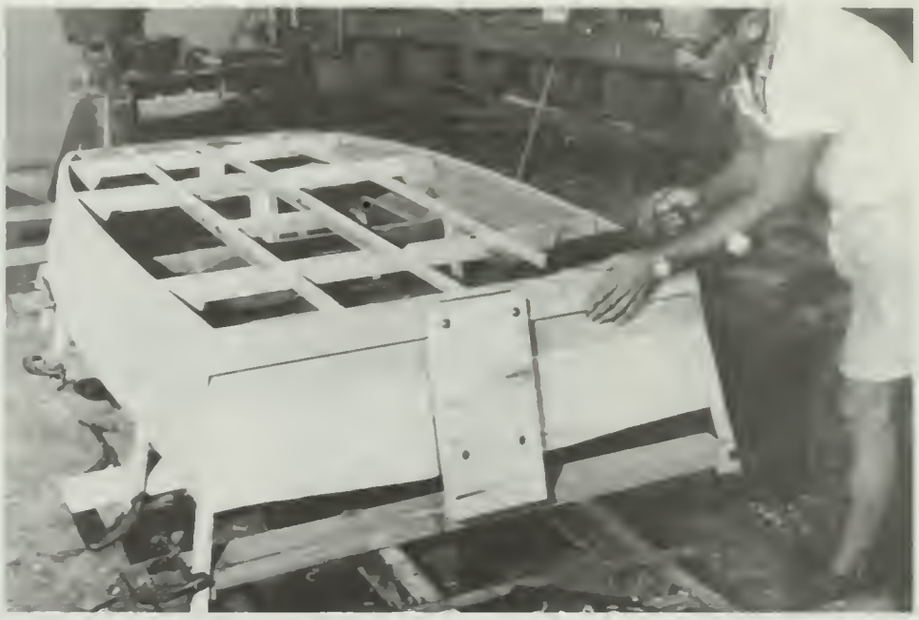




▲ *Bottom battens and chines are in place. Bottom battens are beefed up between ribs #3 and #4 to support glass windows.*

◀ *Ribs are set up on the jig. Note extra length of frame sides fastened to jig crosspieces. Later they will be trimmed flush with sheer clamps.*

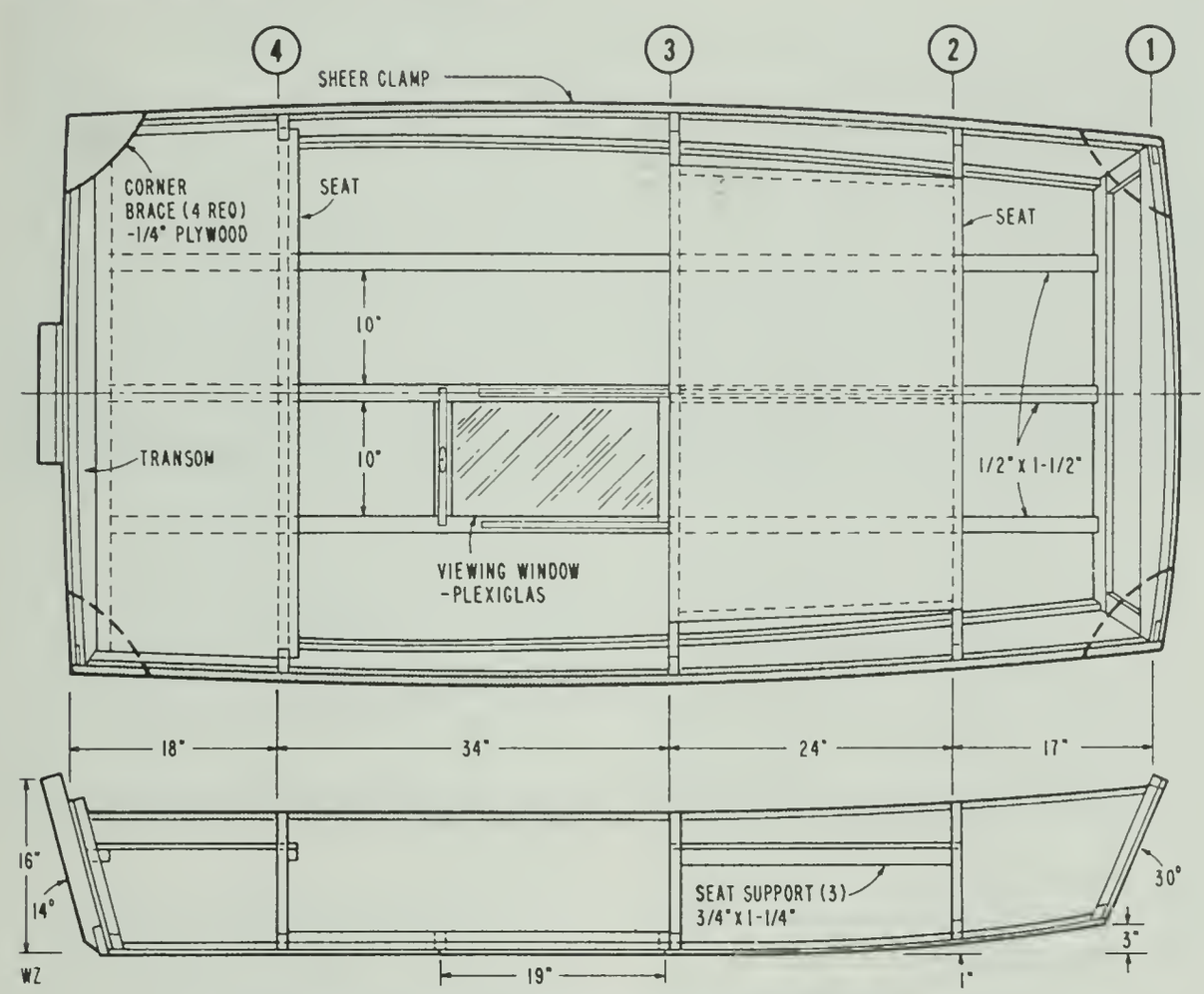


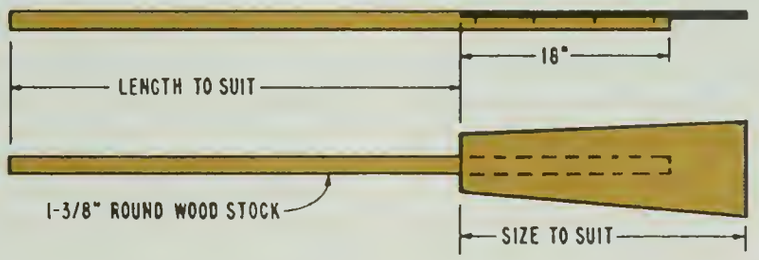


Cut 1/4-inch deep notches in battens near transom so any water in boat can be made to settle in one corner for easy bailing. Note 1 x 2 cross-member, motor mount. Height of motor mount depends upon motor; 16 inches is normal.

Plywood sides are glued and nailed to sheer which in turn becomes rubstake.

Window framing and seat braces are shown. Interior is painted before seats are installed, to reach corners otherwise inaccessible.





OAR

for the framing, but straight grained fir is adequate and more easily obtained. Make up full-size patterns on builder's paper or wrapping paper. Make them up for just half of each frame; draw one half on the stock, then flop the pattern to draw the other half.

Note that bow and transom frame members are half-lapped at the corners so plywood panels will lie flush against the framework. Be sure to notch for battens and chines before installing these panels. Use butt joints backed by ¼-inch plywood gussets on all other frames. You can use ¾-inch bronze #14 boat nails to fasten plywood panels and gussets, after coating mating surfaces with glue.

When the frames are assembled, notch for battens and chines; make the notches wider so the extra space will act as limber holes through which water can drain. Mount the frames on the jig, and align them carefully. They must be centered ex-

actly, perpendicular to the jig (except for bow and transom), and square with the centerline.

Install the three bottom battens, then the chines, using glue and 1½-inch #8 bronze flat head screws at each joint. You can make up full-size patterns for the plywood side panels, or clamp uncut panels in place and trace the outline. In either case, the sheer should be cut exactly to size; ends and chine edge can be left slightly oversize for trimming after installation. Use glue and ¾-inch bronze #14 boat nails to attach the sides to the framework.

Make up and install the framework that will take the plexiglass bottom panel.

Cut the plywood bottom panel to size, and temporarily fasten it in place with one screw in each corner. On the inside, mark the outlines of all frames, battens, chines, and plexiglass panel framing. Remove the panel, cut out the opening for the plexiglass, and drill pilot holes for all nails. These should be spaced about 3 inches apart along chines, bow, transom, and around the window. Space them about 6 inches apart along battens and frames. Coat mating surfaces with glue, then reinstall the bottom panel, hammering ¾-inch bronze #14 boat nails through the pre-drilled holes. Because the battens will have some spring, have a helper under the boat hold a heavy weight against them from inside so you will have something solid taking the hammer blows.

At this point, you can fiberglass the bottom, if desired.

Now drill and countersink screw holes in the plexiglass window panel. Apply bedding compound around its edge, and screw it in place.

Next, remove the hull from the jig, turn it over, and place it on a pair of padded saw horses. For this boat, sheer clamps are rabbeted and attached to the outside of the planking panels. This is the reverse of the usual procedure, but the sheer clamps double as rub rails, and they also provide a protective covering over the exposed edges of the plywood side panels. Now trim the frame ends flush with the sheer clamps.

Install seat braces, then paint or varnish the hull interior as desired. When the finish is dry, install the seats themselves, fastening them in place with ¾-inch bronze #14 boat nails.

About the only hardware needed are oar locks and the bow eye of your choice. You can buy oars, or make up your own easily. Use 1⅜-inch round wood stock, cut a flat section 18 inches long at one end, and glue and nail a ¼-inch plywood blade in place.

H.K.

See also: BOAT BUILDING; BOAT BUILDING PROJECTS; SKIFF, HUNTING AND FISHING; TRAINING BOAT.

MATERIALS LIST

Quantity	Size and Description	Purpose
3	¼" 4'x8' exterior or marine grade plywood	gussets, sides, bottom panels, corner braces and seats
3	¾" 12"x8' white cedar or clear fir	framing, seat supports, sheer clamp and rub rail
1	¼" 10"x19" plexiglass	window
as needed	#8 1½" flat head bronze screws	
as needed	#14 ¾" bronze boat nails	

NOTE: Also need marine glue, paint or varnish, motor mount and fiberglass.

Irregularly shaped pieces are easily cut freehand with a saber saw. Pattern has been traced on good side of this sheet of plywood for clarity of demonstration. Ordinarily, the pattern would be traced on the underside to provide the cleanest edge on the good side. When you do this, remember to reverse the pattern. Another possibility: get a reverse-cutting blade of the type used for plastic laminates. This kind of blade puts the good side of the cut nearest the saw.

How to Use a Saber Saw

This handy power tool can do a variety of jobs. For some of them, it's nearly indispensable

MAKING CURVED saw cuts in large plywood panels too bulky to handle on a hand saw or conventional bench-type jig saw is a typical job where the portable electric saber saw proves its worth. The wide variety of types and sizes of saw blades available makes it possible to saw metal, plastics, sponge rubber, all kinds of composition board and, of course, wood.

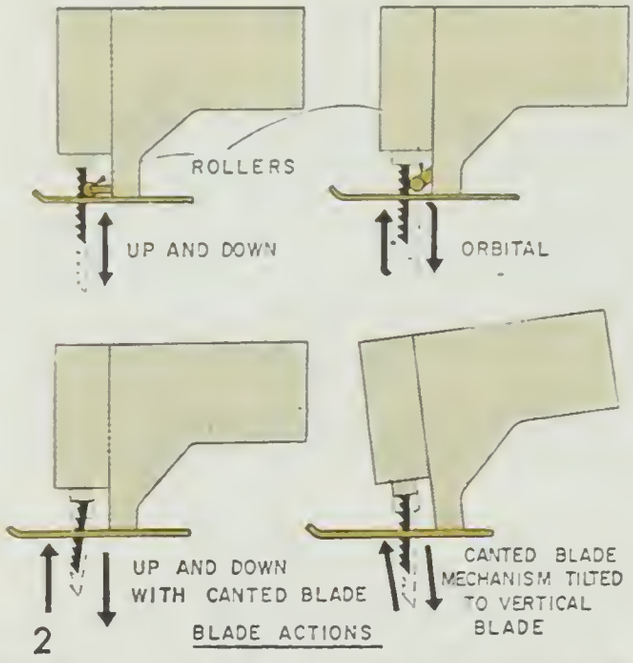
Because of its compactness and light weight, from 4½ to 6½ pounds, portable jig saws are used by the building trades for quickly cutting holes in walls for electrical outlet boxes, heating and cooling ducts, pipes, ventilators, etc.

Portable saber saws may be classified into three types and sizes. The inexpensive machines are satisfactory for intermittent home workshop use. Some models, however, are limited to a cutting thickness of one inch. The medium-price saws will handle two-inch thick dressed lumber (actually 1⅝ inches) and some models have a tilting base for bevel cuts. Heavy-duty saws are built for continuous duty as required by the building trades.

The cutting action of the blade on the various machines differ. Some have a straight up and down stroke, while others have an orbital or canted blade action, which backs the blade away on the downstroke and moves it forward on the cutting or upstroke. This backward movement of the blade on the downstroke frees the kerf or cut of sawdust or metal chips and reduces power-wasting drag on the downstroke. The blade roller supports and guides the blade while cutting.

Since the primary purpose of a portable saber saw is to make inside scroll and straight cuts that are beyond the range of other types of power tools, the type of blade

safelight: see darkrooms
safety, bicycle: see bicycles

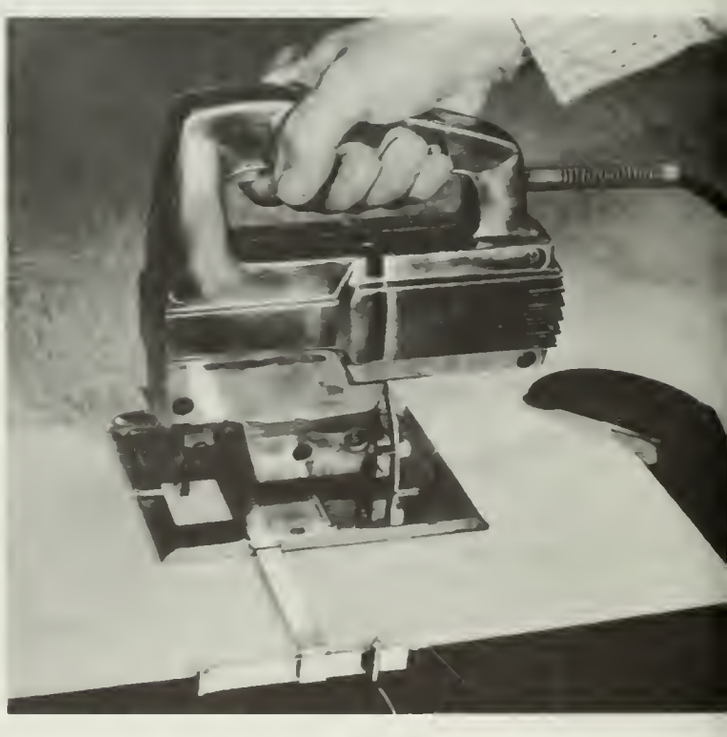


▲ *Circle-cutting attachment produces perfect circles easily. To avoid marring the disk or the round edge, start with a plunge cut on the circumference of the circle. Then attach circle cutter and proceed.*

used can hinder or hasten the work. A good rule-of-thumb is this; the narrower the blade and the wider the set of the teeth, the sharper the turns or corners that can be sawed. For fast but rough cutting of wood use a blade having 6 or 7 spring-set teeth per inch. For smooth finish cuts use a hollow-ground blade. Although you cannot cut as small a radius with a hollow-ground blade as you can with a spring-set blade, often this can be overcome by boring relief holes to match small turns in design.

Because portable saber saw blades are much wider than the blades used on a stationary, bench-type jig saw, don't expect to be able to do the intricate scroll work you can with the stationary type of machine. Instead, design the scroll work with radii large enough for the portable saw blade to follow.

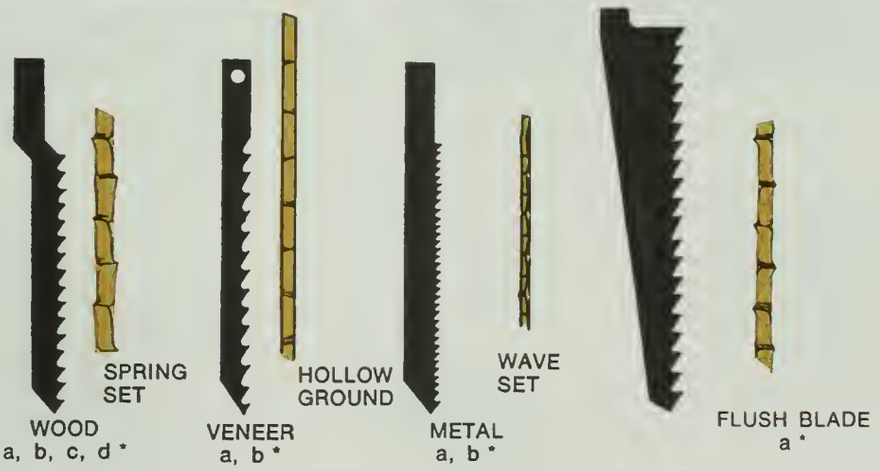
The ability of a portable saber saw to make its own starting hole for inside or pocket cuts eliminates the need for drilling a hole as must be done for a stationary jig saw. To make such a "plunge" cut, tilt the machine forward on the tips of the base. Then slowly feed the blade into the wood, keeping the base tips firmly in place on the



➤ *Use an adjustable rip guide to make a cut parallel to the edge of the board.*

How to Use a Saber Saw

Clamp a straightedge to the work to serve as a guide when making a long straight cut. Keep the edge of the baseplate snugly against the guide as you saw.



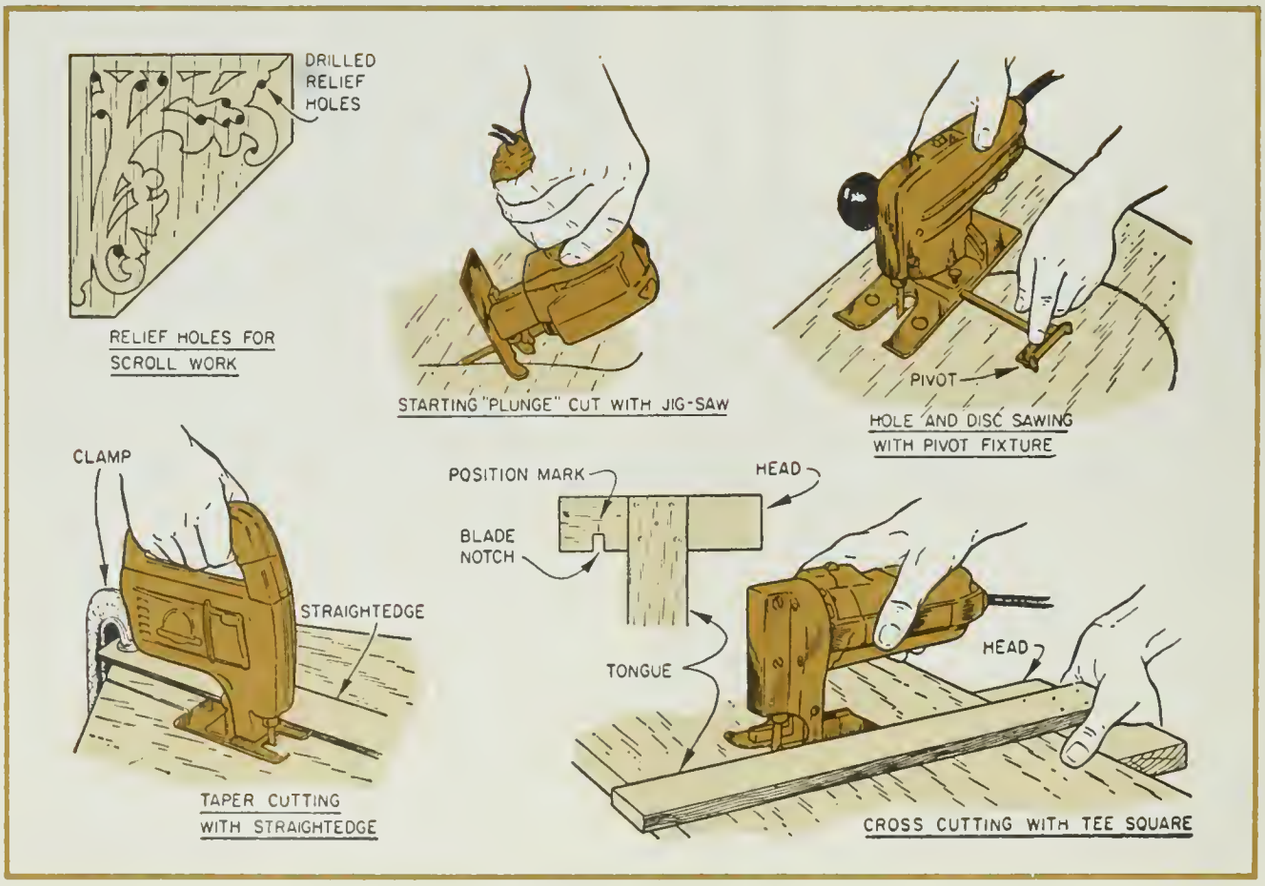
Material	Blade	Teeth per in.	Length	Spring Set	Wave Set	Use				Cut			Hollow Ground
						Straight	Curve	Scroll	Pocket	Finish	Med.	Rough	
Wood	a	7	3″	X			X	X	X			X	
	b	10	3″	X			X	X	X			X	
	c	8	3″				X		X		X		X
	d	6	4″			X					X		X
Veneer	a	6	4″			X				X			X
	b	6	3″				X		X	X			X
Metal	a	14	2⅞″		X	X					X		
	b	32	2⅞″		X	X					X		
Flush	a	7	4″	X		X					X		

▲ *Clamp long narrow stock to bench or to a large sheet of plywood so that portion to be cut off projects beyond the edge.*

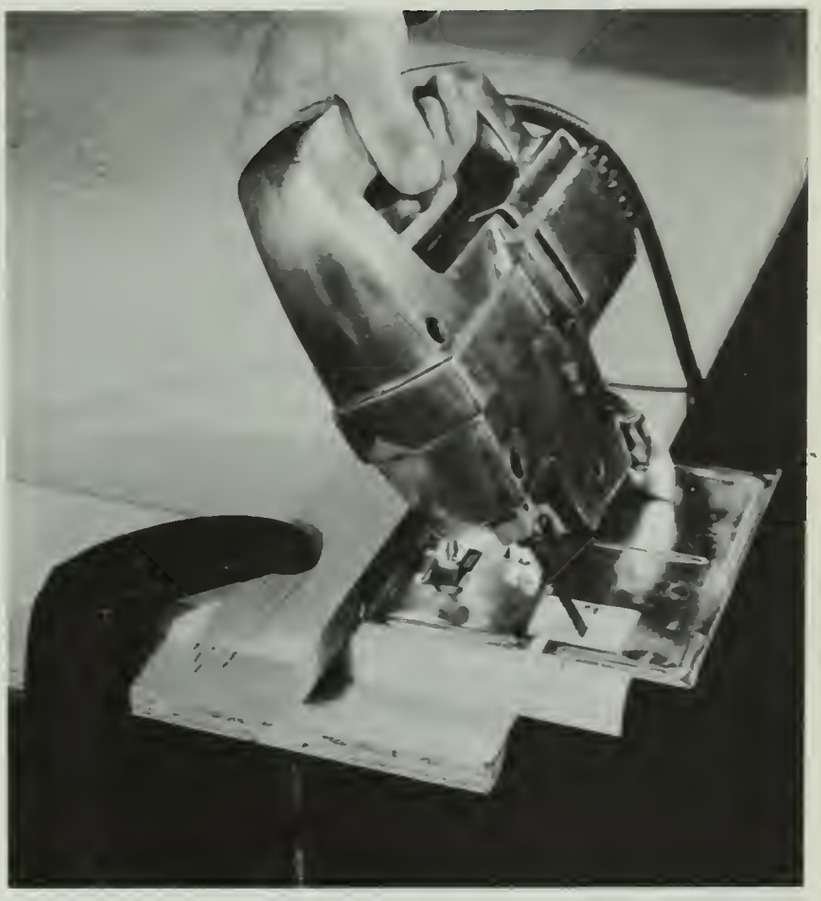
workpiece. When the blade pierces the work, swing the machine down and proceed with the sawing in the normal way.

Feed the saw along the line of cut at a uniform rate of speed so as not to exceed the cutting speed of the saw teeth. Remember the saw cuts on the upstroke only which tends to pull the saw downward firmly against the workpiece. Feeding the saw too fast will place the blade teeth in contact with the forward end of the kerf or cut on the downstroke which will tend to lift the saw and cause vibration.

Since the cutting edge of the saw is in full view, with a little practice you will soon develop the skill needed to freehand-guide the jig saw along curved pattern lines. Although circle cuts can be guided freehand, most jig saws are equipped with an adjustable radius-rod attachment that can be used to guide the saw around a perfect circle. No guide lines on the workpiece are needed. Simply adjust the radius rod so the distance

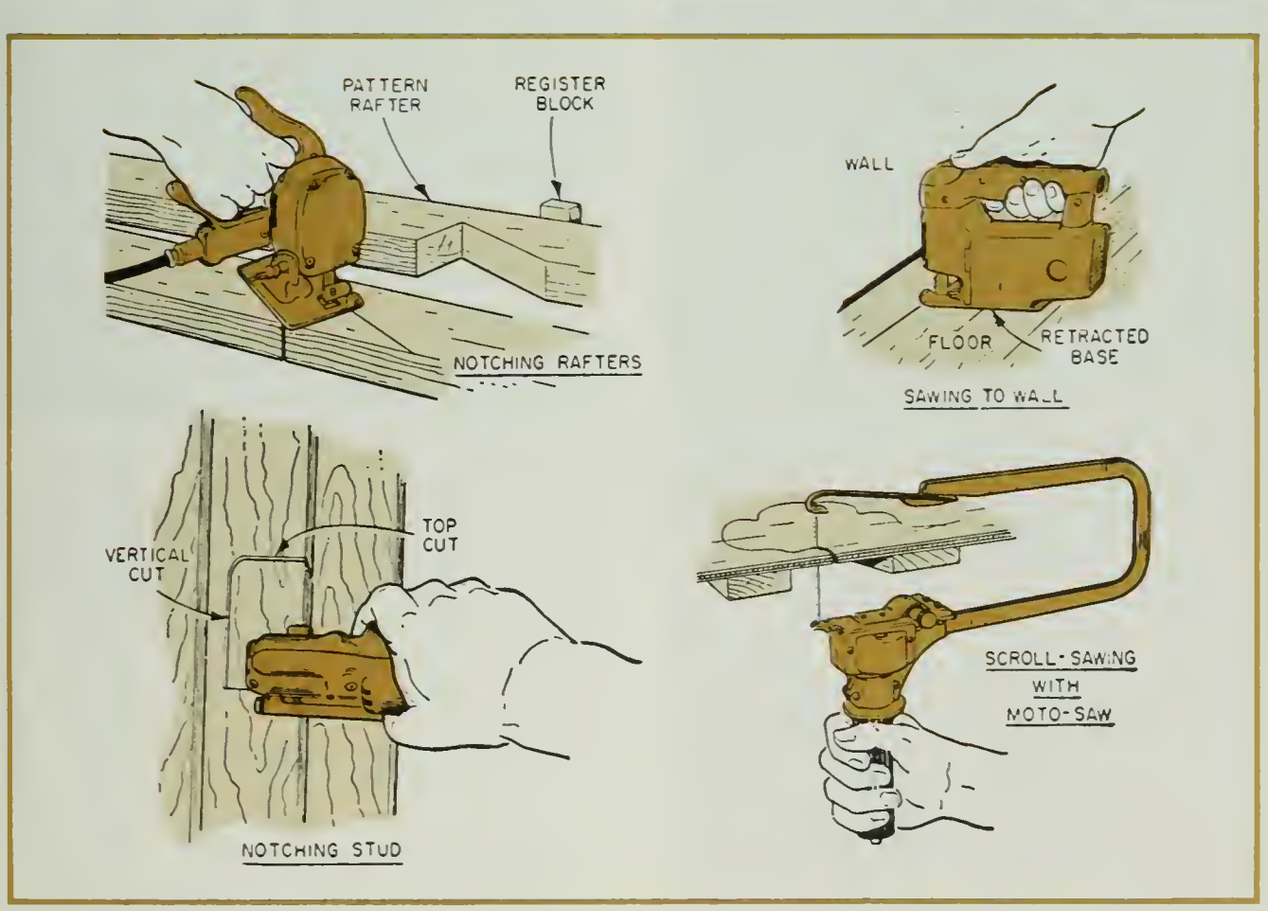


How to Use a Saber Saw 2231

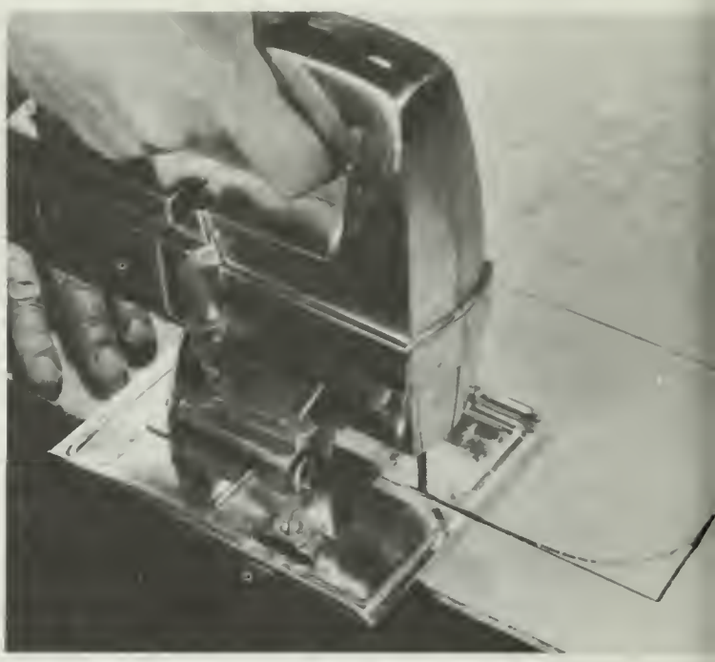


➤ *Saber saw can be tilted as much as 45 degrees on its baseplate for making bevel cuts. To ensure accuracy, move edge of baseplate firmly along a guide block while cutting.*

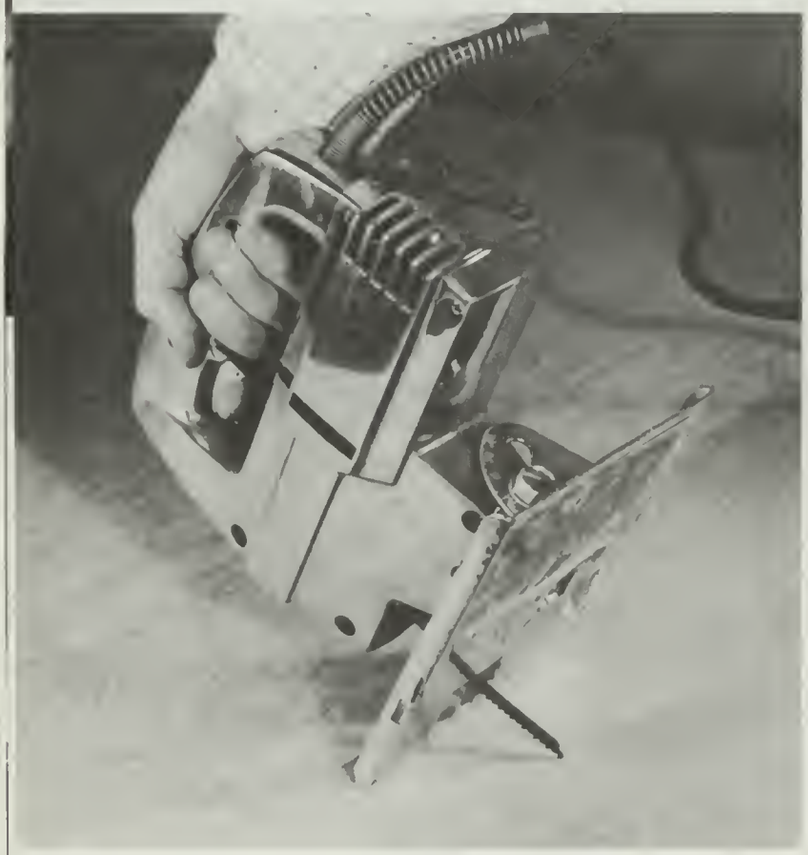
from rod pivot point to a tooth on the blade corresponds to the radius of the circle desired. Measurements to the inside or outside of the blade tooth will depend upon whether the circle or the area around it is the waste piece. Hold the pivot point firmly in place with your left hand as you feed the saw around with your right hand. For ripping or straight-line cuts parallel to an edge, and a short distance from it, insert the jig saw fence attachment, measuring from its head to a near tooth, and saw with the fence head sliding along the edge. To prevent the wood grain from turning the blade to one side and the other producing a weaving cut, use a wide blade, and for smoothness, one with little set. A hollow-

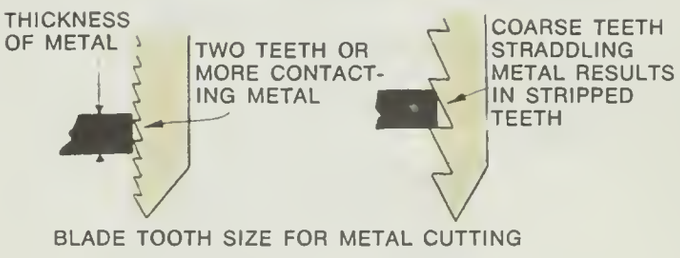


Make an inside corner this way. Cut an easy curve to an adjacent edge, then reposition saw and cut two ways, each toward the corner to remove the small corner piece.



Starting a plunge cut. Tip saw forward on front edge of base plate so blade does not strike wood on its longest downstroke. Then start saw and slowly lower blade tip to wood and continue cutting until the blade passes through the work.





BLADE TOOTH SIZE FOR METAL CUTTING

ground blade will hold splintering to a minimum when sawing plywood and fir.

When cuts are too far from the edge to use the rip fence, or at an angle with the edge, use a straightedge tacked or clamped to the work. Position the straightedge away from the line of cut the distance the saw base edge is from a near blade tooth. Slide the saw base against the straightedge when cutting.

When crosscutting square with the edge of a board, follow a pencil line or slide the saw base against a tee-square made by nailing a strip of wood to a block for a head. A notch cut in the tee-square head allows for blade projection at the start of the cut. Metal adjustable protractor guides can be purchased for use in making square or oblique cuts. When using such helps, make allowance for cutting offset by marking blade position on the guide head.

For house or garage building, the portable saber saw is the only portable power tool that can be used to saw rafter notches. After notching the first rafter, nail register blocks to one end and the upper edge of it and use as a pattern for marking the others. The portable saber saw will also make quick work of notching wall studs for gas or water pipes and electrical conduit. Saw into the stud horizontally for the top cut, swinging the saw downward to make the vertical cut. Then remove the saw and

make the bottom cut of the notch as you did the top.

One model jig saw will make a cut flush with the front end of the saw. This feature makes it particularly useful in the installation of heating and air conditioning ducts. The saw has a retractable base that can be moved back so that the forward edge will be flush with the teeth of a flush-type saw blade. Jig saws having tilting bases come in handy for cutting compound miters on the upper ends of valley and hip roof rafters.

Metal cutting. With metal-cutting blades inserted in the portable jig saw, you can cut any metal that a hacksaw will and to any width because the jig saw does not have a C-shaped frame to limit the depth of cut as a hacksaw does. Use a blade having fine enough teeth so that at least two full teeth are in contact with the thickness of the metal being cut. A coarse-toothed blade will straddle the thickness of the metal and the teeth will either be stripped or the blade will bend or break. When sawing thicker metal, however, a coarse-tooth blade should be used to prevent the teeth from becoming clogged with metal chips. Be sure to grip the metal firmly in a vise when cutting so that vibration will not pinch blade and break it.

When sawing sheet metal, support the underside of it close to the saw blade to avoid buckling of the metal and binding of the blade. Intricate shapes can be cut from thin sheet metal smoothly and with little burr if the metal is nailed between two sheets of thin plywood or hardboard.

Accesssories. Tables to convert the portable jig saw into a stationary saber saw are available. Some tables are grooved for a miter gauge and rip fence, but this setup is usually used for freehand sawing of small pieces.

See also: POWER TOOLS; TOOL TECHNIQUES.

Cut metal pipes, tubes and rods with a suitable metal-cutting blade. Hold the work in a vise or lock it between two boards, using a woodworking clamp. A small screwdriver jammed under the jaw of the clamp will keep pipe from vibrating. Allow the cut off portion to fall freely to avoid pinching the blade.

Inexpensive tables are available to convert saber saws into bench-type jig saws.

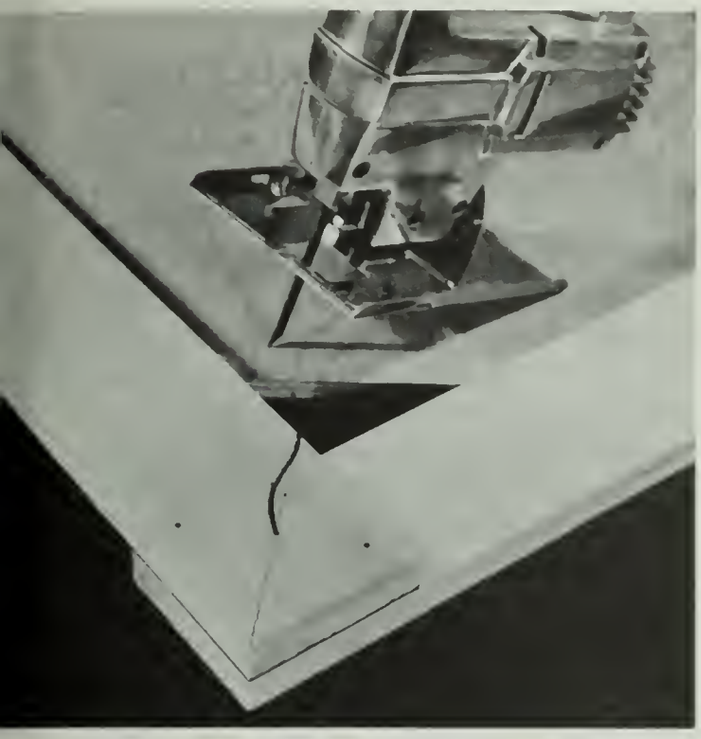
Tricks You Can Do with a Saber Saw

Try a wavy miter joint cut in a way that makes a poor fit impossible, or hinge a door before it actually exists

THE SABER SAW, one of the most versatile of power tools, can perform operations in woodworking that no other tool can do. For example, it can make its own starting hole in a plywood or composition board panel of any size, then proceed to cut either straight or curved outlines of the area of the panel to be removed.

Many of today's saber saws are designed so the blade can be tilted to make bevel cuts, either straight or curved. Earlier models not equipped for tilting can do it with a few simple makeshifts. There are a few tricks that any saber saw owner can do that cannot be done with ready made equipment —such as the cutting of grooves and dadoes, either curved or straight, through the use of shim blocks under the saw's footplate.

Starting cut. To make a starting cut from the center of a panel, simply stand the saw on its nose so that the tip of the blade is in light contact with the surface of the wood to be cut. Then start the saw and gradually tilt the saw blade into the wood. Do not bear down heavily. Ease the blade in to avoid excess pressure that might break it. Once the blade has penetrated completely shut off the saw. When the blade stops, slide it back, set the saw footplate flat on the panel surface, with the blade projecting through the starting cut, and continue the cut along the marked line. There is no need to drill a starting hole that in most cases make the cut-out section unusable as a door in the opening that has been cut. Thus, with a saber saw, you can cut a door opening in a piece of plywood and use the cutout section as the door—and the fit will be perfect. This leads to the seemingly impossible trick of hinging a door before it actually exists. Here's how you do it—tilt the saw blade into the panel as described (some people call this starting cut a "plunge cut"). and make a complete cut along one side of the door outline. Make another cut along the opposite side. Finish the first stage by making the cut that joins the other two. This cut represents the hinge side of the door. Next, mount the hinges across this cut. The panel that is to be the door is still a part of the major panel as it is not yet cut free. After the hinges are mounted make the fourth cut, once again joining the two first cuts. This last cut is the latch side of the door, and it frees the door from the panel. You can now swing it open and it can't be anything but a perfect fit because the hinges were mounted while it was still a part of the overall panel.



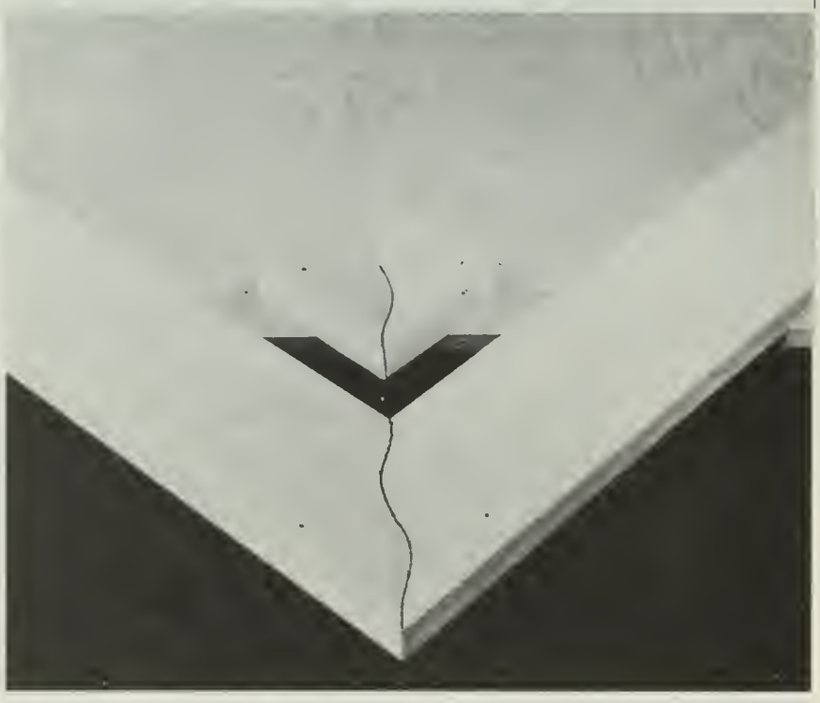
To make a miter joint, overlap the two pieces and nail together, then cut both pieces simultaneously. Saw is backed off to show wavy miter cut that is half completed. For a standard miter, make a straight cut.

Cutting grooves. Groove cutting with a saber saw can be accomplished in two ways, use a short blade, or shim up the footplate of the saw so the regular length blade penetrates only to the desired depth. (Saws that take plain-end blades can use short sections of old broken blades for this purpose.) Either way, arrange blade length or shims so the blade tip penetrates to the depth you want on the down stroke. Do not set any depth arrangement that will permit the blade tip to rise completely out of the wood on the up stroke. This will simply hammer the blade repeatedly against the upper surfaces of the panel and break it. If you want to make a cut shallower than the length of stroke of your blade, there is a semi-solution in buying a low cost vibrator type saber saw. These have a very short blade stroke which enables you to do this type of work without lifting the blade tip out of the wood. Ultrafast blade motion assures a smooth-surfaced cut. Once the blade depth is adjusted, the saw can be guided over the work in the same manner as in through-cutting.

The simplest way to attach the scrap wood shimfeet under the saw's footplate is with double coated pressure-sensitized tape. (Tape that is sticky on both sides.) You can buy this from large paper dealers. Simply stick it to the upper surface of the wood shim, peel off the separator strip (as on a tire patch), and then stick the shim to the underside of the saw's footplate. This will hold the shims in place for an average length job. For extended work it may be necessary to re-fasten the shims or, if the saw design permits, drill bolt holes through the footplate so they can be bolted in place.

To cut a bevel with a saw not designed for bevel cutting, simply use the shim system described, but attach the shim to only one side of the footplate so that the saw is tilted. Do not use this system for a starting cut in the panel center. To avoid

The accurate fit of wavy miter proves that you don't have to worry about cutting a perfectly straight line if you cut both miters simultaneously. Note scrap pieces also fit together.



blade breakage, start your bevel cuts from a drilled or bored starting hole.

For a clean-edged cut use the saber saw with the finished surface of the wood down, following an outline penciled on what will be the underside or concealed surface of the wood. Saber saw blade teeth are usually angled so they cut on the upstroke. This tends to hold the saw firmly against the work. Also, it tends to fray cut the fibers of the wood along the edges of the cut on the upper surface. It is not always convenient to cut out plywood parts with the panel wrong side up. This is especially true where a number of "left" and "right" type of parts must be cut. There's a very simple trick that enables you to cut any wood or plywood with the finish side up without fraying out fibers along the cut. Merely cover the penciled cutting line with cellulose tape. Press the tape firmly in place by sliding an old spoon along it. On curved lines use small sections of tape overlapped slightly at the ends. This lets you cover the curved outline with a series of short pieces of tape. When you make your saber saw cut, it is easy to see the pencil line through the tape, and the tape prevents fiber fraying. To see just how effective this system is draw a line along a scrap of plywood and cover part of it with the tape. Then make a test cut through the taped section and into the untaped section. You'll note a razor-clean cut edge along the taped section, a frayed one along the untaped portion. After the cut, just peel off the tape. Some of the very short stroke vibrator type saber saws cut on the down stroke and can therefore cut with the finish surface up without tape protection along the cutting line. But this type of saw is generally designed for relatively light work.

The easy tight-corner cut. When a woodworking job requires a narrow rectangular notch to be cut in from a panel edge, or a narrow rectangular hole in the panel, there's a simple way to do the job without risking blade breakage. Cut along the straight outline toward the corner but steer your blade (before you reach the corner) into a gentle curve toward the opposite corner, ending the cut at that corner. Now cut inward along the opposite side until this straight cut meets the previous curved one. If you're notching in from an edge, this frees the waste section. All you need to complete the job is to cut straight in along the other side to remove the waste section remaining. Small irregularities can be "shaved" straight by easing the side of the blade along them. Do not press the blade sideways. Simply guide it straight forward.

Getting maximum blade life. A good saber saw blade will last a long time if treated properly. Rule one—don't force the blade. The added friction slows the saw. Excess pressure causes back flexing in the blade shank that result in metal fatigue and breakage long before it would otherwise occur. Increased friction in thick wood sections may also overheat the blade enough to draw the temper. (Misused blades can actually overheat enough to leave scorch marks along the cut edges.)

When a cut ends within a panel area, or without running all the way through a piece of lumber, wait for the saw to stop (after you switch it off) before lifting it out of the wood. If you lift the blade out of the cut with the saw running, or before it slows to a stop after shuttting off, the blade tip may strike the panel surface on the next down stroke with enough force to break the blade.

If you are cutting all the way through a piece of lumber, provide support for the piece that will be cut off, especially if it is a thick or heavy section. As the waste piece falls it tends to tilt its lower edge inward against the blade. If it's a heavy piece like a 2 x 8, it can actually break the blade. If it's supported, or hand-held to prevent it from falling, the blade is safe.

If you're cutting green or pitch wood

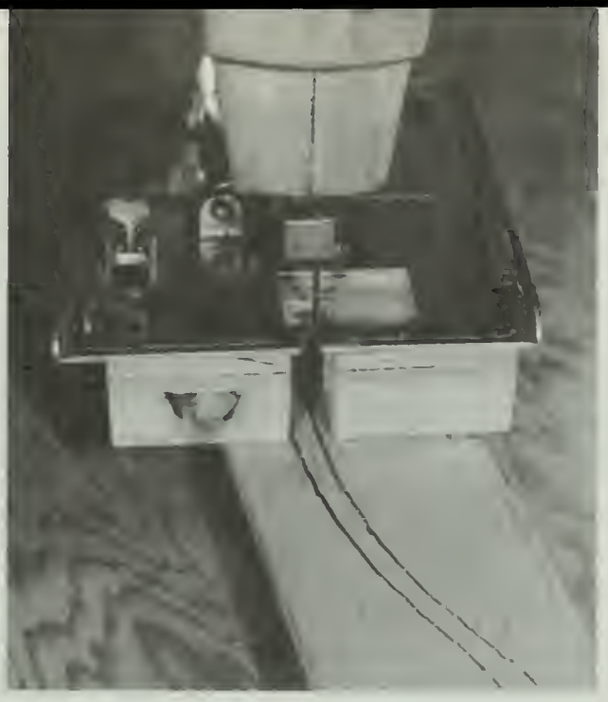
use the coarsest blade available. If the blade is laboring, stop the saw and remove it from the wood at frequent intervals to prevent overheating.

In some woods such as fir, there is considerable difference between the hard and soft sections of the grain. In cross cutting and in angle cutting you can actually feel the saw jump ahead through the soft areas and then slow abruptly as it hits the hard grain of the wood. This can strain and eventually break a blade if the hand pressure behind the saw is excessive—even though the same pressure would be proper for sawing other woods. The trick is to use very light pressure—allowing the saw to "race" slightly. The added blade speed cuts the hard sections without the abrupt bumping.

In any saber saw work hold the saw firmly against the wood surface, especially when working with green or pitchy wood likely to cause binding. Firm down pressure prevents the saw from "jumping" if it should strike a pitch pocket.

How long should a blade last? There is no set rule for blade life. Some types of work wear a blade much faster than others. Properly handled, a quality blade is good for months of average workshop use. In a sample case, a single blade was used to cut all the parts for two 15-foot outboard boat hulls and was in good condition when the job was finished.

If you happen to break a blade before it has seen much service it is often possible to continue using the remains, if the lower section is long enough. As stresses are greatest just below the point where the blade is clamped in the saw, breakage is most likely to occur at this point, leaving a considerable length of usable blade. If your saw is one of the common types that takes a blade with a plain straightedged clamping shank, you can grind off the "set" (outward bend) of the teeth and trim a short section to fit in the clamping slot. The blade is still good for use on thinner stock. Metal cutting blades used on sheet metal can be re-used easily in this manner. The section of the teeth put to work is likely to have received little wear. Caution—never attempt to re-use a blade section so short it is likely to lift its tip completely out of the work.



To cut grooves, test blade against thick plank as a two-by-four to measure total depth of cut. Then make a block from scrap wood to fasten under the saw baseplate. Thickness of the shim block determines how deep the blade will cut in wood to be grooved. Block can be fastened quickly to baseplate using double-faced adhesive tape used to hold down carpeting. Note blade notch in front of block.

After sawing partially through the work using a shim block, remove waste wood with a sharp chisel.

See also: POWER TOOLS; TOOL TECHNIQUES; WOODWORKING.

What to Do about Boating Accidents

The unwritten law of the sea, river and lake is that a boatman must stop to help another in distress. If you are ever called upon for aid, here's how to go about giving it

THERE'S AN UNWRITTEN LAW that boatmen have always observed: help fellow boatmen in distress. This unwritten law gets an assist from one that's on the books—the "Good Samaritan" provision of the Federal Boat Safety Act of 1971—that says you can't be held liable for any damage or injuries caused by your actions if you take the steps any prudent skipper would follow in the circumstances.

The two most common emergencies in which your help would be needed are the boat that has an engine problem and needs a tow, or the boat that has capsized, swamped, or sunk, with survivors that need to be picked up.

Towing disabled boat. Your first problem is to get a line across to the other boat (or take a line from it). In fairly calm seas you can come close alongside, so the line can be tossed over. If it's rough, you can tie the end of the line to a life preserver and let it drift across so that it can be picked up with a boat hook, or you can circle around the boat, trailing the line, and then pull it up along the disabled craft.

On your boat, make the tow line fast as far forward of the rudder as possible; otherwise you'll lose all steering control. If possible, rig a bridle as shown in the diagram. Since towing imposes a considerable strain on the line, it must be secured to hardware

safety, electrical: see wiring, electrical
safety glazing: see storm doors and windows
safety, power tool: see power tools

of ample strength. If the line is long enough, make a loop around cabin superstructure if necessary.

When you are under way, the tow line may break, or the towed boat sink (if it has suffered hull damage). Be prepared for either eventuality. If the line breaks, the whipping action of the broken line as it snaps back is extremely dangerous. Keep everyone clear of the line, and forward of the point at which it is fastened.

Notwithstanding the above, make sure someone is stationed where he is protected, and yet is in a position to cut the line if the towed boat should suddenly sink. He'll need an axe or a sharp knife.

On the boat to be towed, it's best to secure the tow line as low as possible. This helps to keep the bow up as the boat is pulled through the water. On a small runabout it may be possible to lean over the bow and secure the line to the bow eye. If this is not possible, use the regular bow cleat, or forward bitts, if they are strong and well-fastened to the deck. Of course this is the responsibility of the skipper of the disabled boat; he should know if his deck hardware is bolted through sturdy backing blocks or just to the deck itself.

If the boat is fairly large, it is best to loop the tow line around the hull, below the line of the gunwale. Short lengths of line, attached to deck cleats or rail stanchions, will prevent the tow line from dropping under the boat.

If the water is rough, you, as skipper of the towing boat, should adjust the length of the tow line so both boats are at the crests of waves at the same time, and in the troughs at the same time. This is to keep as even a strain on the tow line as possible. Of course this is an ideal situation; the waves never cooperate.

All the foregoing applies to towing free a boat that has gone aground, as well as one that is adrift. If the boat is aground, however, you will be towing it stern first, and its skipper must rig his end of the line accordingly. Again, it's best to run the line around the hull to spread the strain over as much area as possible.

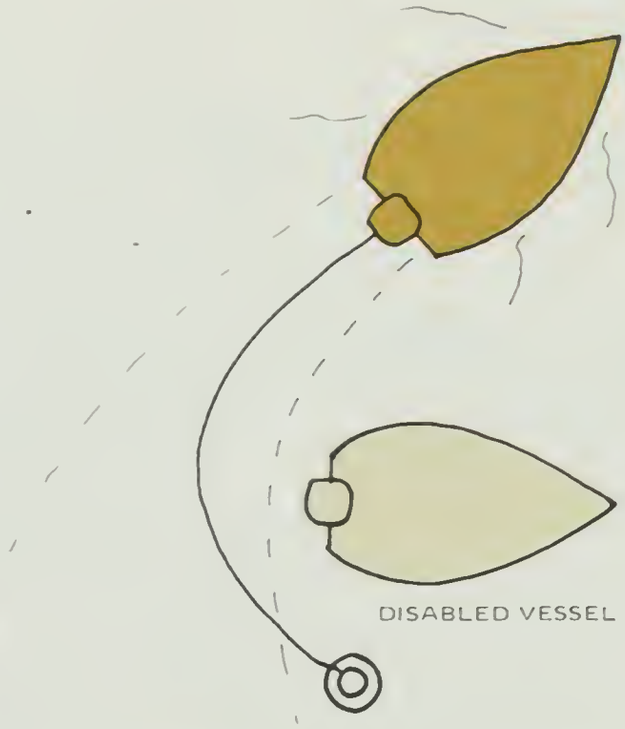
Take up the slack on the tow line as slowly as possible, then apply enough power to pull. Too much power and your propeller will lose its "bite" and you won't accomplish anything. If the boat does not pull free, try zigzagging to help work it off.

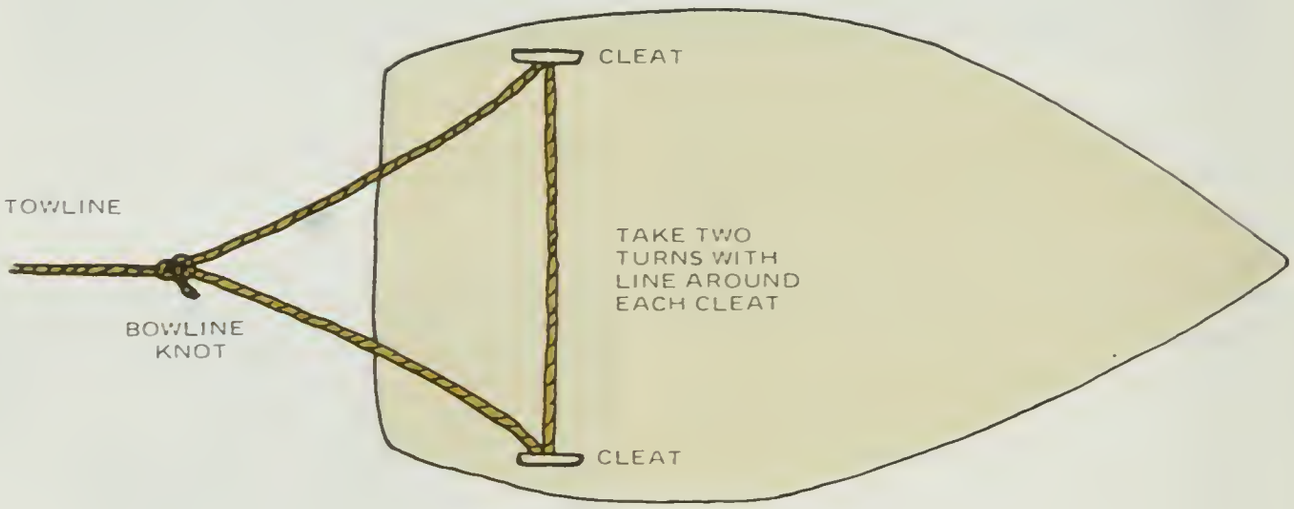
If the boat is solidly aground in a tidal area, you may have to wait for the tide to rise. In any case, try to take aboard your boat as much gear and crew as you can handle safely. This will help lighten the stranded boat.

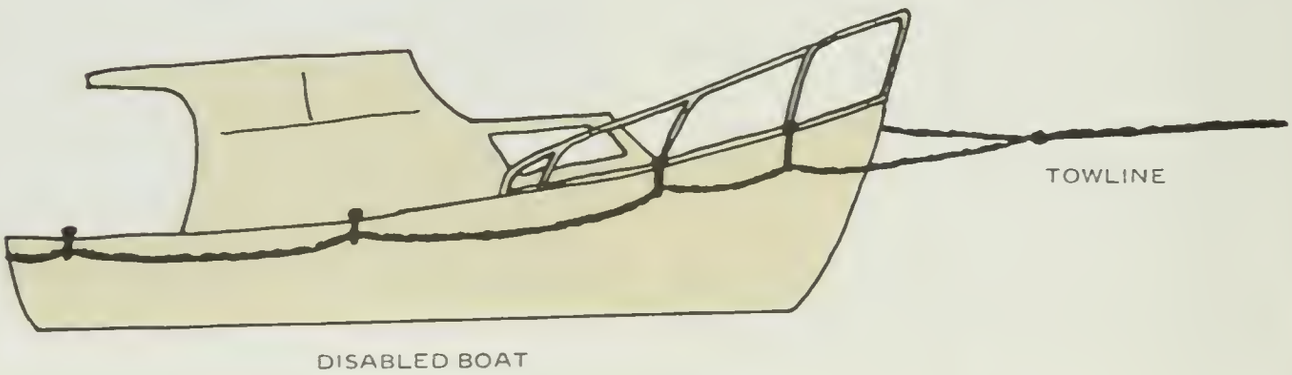
Suppose all your efforts fail, and there's no tidal action that can float the boat free. What can you do? Your best course is to go for professional help, marine police or the Coast Guard.

Picking up victims from water. What do you do when there's been a boating accident, and there are victims in the water—or you are faced with a "man overboard" from your own boat?

Using a ring buoy and line to haul the victim of a boating accident alongside.


DISABLED VESSEL


CLEAT
TOWLINE
TAKE TWO
TURNS WITH
LINE AROUND
EACH CLEAT
BOWLINE
KNOT
CLEAT


TOWLINE
DISABLED BOAT

First get flotation aids to the victims—life preservers, cushions, or whatever is available. If it's a "man overboard" situation, have one of your crew do nothing but keep an eye on the victim as you slow down and return to the scene.

A line attached to the flotation device is desirable, if you are moving slowly as you approach the victim. As soon as he takes the life ring, preserver, or cushion, take your engine out of gear and pull him gently to your boat.

If no line was attached to the flotation device, approach the victim slowly, against the wind or current—whichever gives you the best control over your boat. Have a boat hook ready, and as you maneuver alongside the victim, take your engine out of gear or shut it off completely. If the victim should slide under the boat, you don't want that propeller spinning!

When the victim is alongside your boat, your next problem is to get him aboard. Ease him to the point where the gunwale is lowest, and pull him aboard. *Never* go in the water yourself to help, if you are alone in your boat, unless the victim is elderly or injured to such an extent that you have no other choice. If you must go over, rig a loop of line as a foot rope so that you can get back aboard yourself.

In some cases the victim may be too exhausted, cold, or heavy to pull aboard. Tie a loop of line under his shoulders, ease him as far forward as possible along the boat, and tie the inboard end of the line to your bow cleat. Then proceed to shore or the nearest point where the victim can get help.

Other assistance. Many "Good Samaritan" situations are not so desperate as the above. Suppose you answer a distress signal from a fellow boatman, and learn that he ran out of gas? Pass over enough from your supply so he can get to a gas dock.

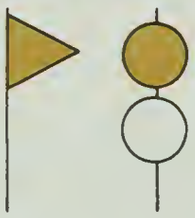
When you maneuver alongside another vessel to transfer fuel, or any other supplies, be sure to rig enough fenders to prevent damage to either hull, and exercise caution in making the transfer. You don't want to go overboard between the boats!

Other things that may be needed are tools, water, a hand pump, or even navigation assistance. Give whatever you can; you can make arrangements to get equipment or supplies back later, if necessary. Next time it may be your boat that's in trouble, and you would want all the help you can get. T.B.

See also: BOATING; EMERGENCY BOAT REPAIRS.

WARNING DISPLAY SIGNALS

SMALL CRAFT *

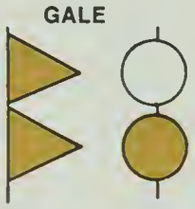


DAYTIME: Red Pennant.

NIGHTTIME: Red Light Over White Light.

Indicates: Forecast winds as high as 33 knots and sea conditions considered dangerous to small-craft operations.

GALE

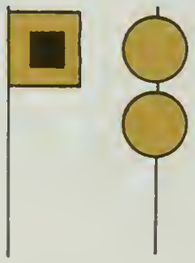


DAYTIME: Two Red Pennants.

NIGHTTIME: White Light Over Red Light.

Indicates: Forecast winds in the range 34-47 knots.

STORM

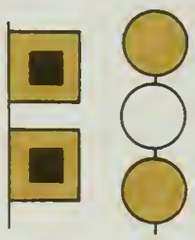


DAYTIME: Square Red Flag With Black Square Centered.

NIGHTTIME: Two Red Lights.

Indicates: Forecast winds 48 knots and above no matter how high the wind speed. If the winds are associated with a tropical cyclone (hurricane), storm warnings indicate forecast winds of 48-63 knots.

HURRICANE



DAYTIME: Two Square Red Flags With Black Squares Centered.

NIGHTTIME: White Light Between Two Red Lights.

Indicates: Forecast winds of 64 knots and above, displayed only in connection with a hurricane.

How to Trailer a Boat Safely

Hauling a boat trailer with a car is not difficult, but it's important to keep in mind that you have a lot more weight back there than you are used to, and to follow a few simple safety checks

IT'S EASY TO TOW a boat on a trailer behind your car, almost as easy as driving just the car, once a few basic principles are understood. There's a lot of weight behind the car; how it is set up, how the car is set up for it, and the manner in which it affects the car's performance all must be considered.

First, the trailer itself must be adequate for its job. It must be rated not only for the weight of the boat itself, but the motor, fuel, water, cushions, personal flotation devices, lunches, beverages, fishing gear, tools, water skis—everything else that is carried in the boat when it's on the road. It's better to have a trailer that's a little too big than one that's not strong enough.

Rollers and bunkers must be adjusted to give support to the boat along the length of the keel, with extra support in the area of the transom to take the weight of the motor. The boat should be able to slide off the trailer easily when launching, and load easily when it is retrieved from the water.

Weight must be distributed in the boat on the trailer so that the weight at the trailer tongue is about 5% of the total load—usually about 75 to 100 pounds. This can be checked by placing a bathroom scale on a box at the appropriate height, and placing the trailer tongue on the scale platform. Correct tongue weight is extremely important in eliminating dangerous trailer side sway at highway speeds.

Two other factors that influence trailer behavior are tire pressure and the hitch you use on the car. Tire pressure is extremely critical and the correct pressure should be maintained. Check pressure when the tires are cold, not after the rig has been on the road for a time.

Never, under any circumstances, tow a trailer with a bumper hitch. In most states this is illegal. First of all, such a hitch is weak; the bumper itself is relatively weak, and any sudden stress could tear the whole assembly off the car. Secondly, any side pressure on the hitch is transmitted to the car well behind the rear axle; it feels as if a giant hand is trying to shove the rear of your car off the road. It's dangerous.

Use a frame type hitch. This is a strong unit that transmits all strains to the frame of the car, usually just ahead of the rear

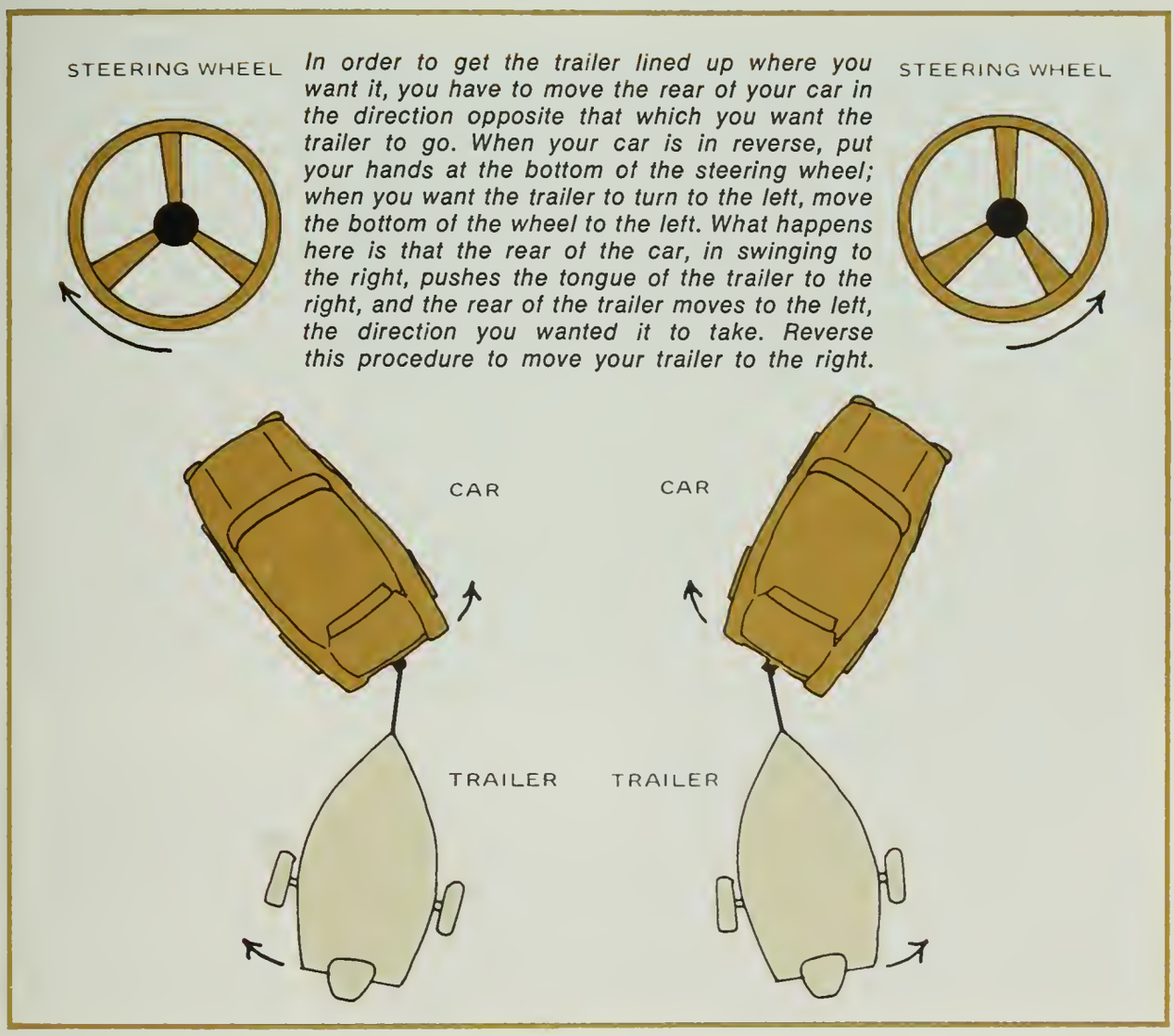
axle. This adds considerably to the stability of the car itself, and will help the trailer maintain a straight track even if tire pressure or loading conditions are not correct.

When you are satisfied with the loading, tire pressures, and hitch, check to be sure the tie-downs are fastened, that the motor is in its recommended position for trailering, that all pennants, flags, and fabric tops are stowed, and that no loose items can blow out of the boat. Now, are you ready for the launching ramp?

No, not if you've had no previous experience in towing and maneuvering a trailer. Wait for Sunday morning, and head for the shopping center parking lot. On Sunday, at least one section of it should be clear, and with its lane markers, it's a great place to practice turns and backing.

On your way there, several things will be noticed. It's harder to get your car moving, acceleration is slower, and (unless the trailer is equipped with surge brakes or electric brakes) it is harder to stop. Hopefully you will not learn the hard way that you can't cut as close to the corner when you make a turn. These effects all become more pronounced at highway speeds, but first practice your slow-speed maneuvers in the parking lot.

It should take just a few hours in each direction, while driving forward, to get a good idea of the clearances needed for rounding normal intersections in town or



In order to get the trailer lined up where you want it, you have to move the rear of your car in the direction opposite that which you want the trailer to go. When your car is in reverse, put your hands at the bottom of the steering wheel; when you want the trailer to turn to the left, move the bottom of the wheel to the left. What happens here is that the rear of the car, in swinging to the right, pushes the tongue of the trailer to the right, and the rear of the trailer moves to the left, the direction you wanted it to take. Reverse this procedure to move your trailer to the right.

city. The hard part is (a) backing in a straight line, and (b) making turns while backing. Since both are needed at the launching ramp and your home, you'll spend some time practicing these.

The secret is to get the trailer lined up in the direction you want it to go,-then follow it with the car. In backing in a straight line, the tendency is to oversteer; keep steering wheel movement to a minimum. It's like the old skippers used to tell novice helmsmen: "Steer small!"

In order to get the trailer lined up where you want it, you have to move the rear of your car in the direction *opposite* that which you want the trailer to go. When your car is in reverse, put your hands at the bottom of the steering wheel; when you want the trailer to turn to the *left,* move the bottom of the wheel to the *left:* it's easy to remember this way, and it will get the car and trailer started in the correct direction.

What happens here is that the rear of the car, in swinging to the right, pushes the tongue of the trailer to the right, and the rear of the trailer moves to the left, the direction you wanted it to take. The action is shown in the diagrams.

If you continue to maintain the angle of your turn until the trailer is pointed where you want it, it's too late. As you straighten out the front wheels of the car, the trailer will *continue* to turn, in a decreasing arc, until the trailer, car, and front wheels are all in a line. So start to straighten out as the trailer approaches the line you want to take. This is what takes practice. At first you'll find that the trailer won't even start in the right direction, or that it will turn too fast in too short a distance; it's "jack-knifed."

When you are satisfied with your ability to control the rig in slow-speed maneuvers, both forward and in reverse, you are ready for the open road. But when you get out on the highway, it's not practice! Three things to be kept constantly in mind are speed, clearances, and stopping distance.

Turnpike speeds of 60 to 70 miles an hour with a trailer are dangerous; most states limit trailer rigs to 50 miles an hour or so on the superhighways, and less on secondary highways. Remember that most trailer wheels are much smaller than your car's wheels, they have to turn much faster in order to travel the same distance. This increases internal tire heat, heat increases tire pressure. Too much pressure causes excessive tire wear at the least, and blowouts at the worst.

Also, a trailer has a lot of surface exposed to cross winds, well up off the road.

Trailer safety checks are recommended at intervals during a long trip. A stop alongside the road not only reassures you of the boat's security, but gives everyone a chance to stretch legs and relax.

A family member helps by acting as a guide when the trailer is backed down the ramp. The rig should be stopped a few feet short of the water so motor can be tilted up, and tie-downs removed.

With trailer backed into the water, this trailer bed can be tilted to allow boat to slide off. Once the boat is afloat, the winch line is cast off, and the bow line is used to control boat's position.

Cross winds not only try to push the trailer to one side but to tilt it over. The faster you go, the more dangerous this becomes.

Keep an eye on your trailer as you drive. This doesn't mean you're taking attention from the road ahead; just check your rear view mirrors occasionally. You should have mirrors that extend well out on each side of the car, so you can see what's behind the trailer on the road.

Make sure the trailer is tracking properly, without wandering or swaying from side to side. Keep speed down if there's any such problem, and pull off at a convenient spot to check weight distribution—you will have checked your tires before you started,

of course. If you find that this is a problem you cannot correct, take your rig to your dealer at the first opportunity, and have him check it. Adjustments to the positioning of the boat on the trailer may be necessary.

Don't tailgate. Even without a trailer this is a foolhardy practice, and if you're towing a trailer it's suicidal. *If the car ahead has to make a panic stop, there's no way you can avoid hitting it!* If you don't hit it with your car, you'll get it with your trailer. The best driving practice is to assume that the car ahead *will* make a panic stop, and maintain distance accordingly. Without a trailer, one car length for every 10 miles an hour is considered adequate. With a trailer, double that.

Even if you are coming up behind a slow moving vehicle that you want to pass, allow plenty of room, and plenty of time, to get around him. On a superhighway, make sure there's no faster traffic coming up behind *you* before you swing out into the passing lane. If possible, change lanes while you are still well behind the vehicle ahead. If you have to slow down to its speed, it will take you longer to accelerate up to passing speed once you are in the passing lane.

On an old-fashioned two-lane highway, you have to be sure there's no traffic coming toward you before you swing out to pass. If there are lots of hills, curves, and oncoming traffic, you'll just have to maintain the slow pace behind the vehicle ahead of you. You may go miles and miles before you have a safe place to pass. Relax and enjoy the scenery.

Remember that you are the slow traffic in relation to normal passenger cars; show courtesy to these faster vehicles. On a superhighway, keep in the right hand lane except to pass. On the old-fashioned two-laner, if cars start to pile up behind you, pull off onto the shoulder for a few minutes to let them get by.

If your trip is of any length, you'll want to pull off the road at intervals in any case, no matter how super the highway. At least once an hour it's best to inspect the hitch, the safety chains, the positioning of the boat on its rollers and bunkers, and all the tie-downs. You'll have the security of mind in knowing the rig is riding well without problems, or the chance to make any corrections that may be necessary. You'll have a chance to relax from the tension of driving, and your family will have a chance to stretch their legs.

At the launching ramp, you'll put to use the techniques you practiced in the parking lot, with the addition that you'll launch the boat, and later retrieve it. First, pull off to one side; there may be a special preparation area, but keep clear of the actual ramp until you are ready to launch, the ramp is clear, and it is your turn.

Remove from the boat any items that were carried in it that will not be used while you are boating (tent, sleeping bags, etc.), and stow these in the car. Remove from the car and stow in the boat items that you *will* need, such as compass and charts. Disconnect and stow tie-downs in the car. Disconnect and remove trailer tail lights or other lights that may be submerged during the launch, or protect them as much as possible against the entry of water. You can cover the entire housing with a plastic bag secured by rubber bands; it helps.

Don't rush to get your boat in the water. Let the trailer wheel bearings cool off before you back the rig into the water. Air inside the bearing caps gets very hot when the trailer is on the road. If the caps get chilled suddenly by immersion, this air cools and "shrinks," literally sucking water into the bearings. While bearing seals may be advertised as watertight, they may not be immune to this suction action.

When everything is ready, put your family to work. One can act as a guide to help you get lined up properly, and to let

you know when to stop. The other holds the boat's bowline, ashore, so the boat won't drift away once it's afloat.

Back down until the rig is a few feet from the water. Your "guide" then can unlock the bow winch, make sure the motor is tilted up, and that all tie-downs have been removed. Then back up again until the trailer wheels are in the water. It is best *not* to submerge the wheel bearings, but unfortunately it often is necessary to do so. Set the hand or emergency brake, and shut off the engine with the automatic transmission in "park," or a standard transmission in first gear or reverse.

Now you can launch, using the trailer's tilt mechanism, if so fitted, or just by pushing the boat free. As soon as it is afloat, it should be led to one side of the ramp by your crew, alongside a pier if one is present, or some other suitable location where everyone can load aboard it. Get back in the car immediately, and get your rig clear of the ramp and into the authorized parking area as soon as possible so the ramp will be clear for the next user.

To retrieve the boat, reverse the procedure. Pull in clear of the ramp itself. Get your rig and back down to the water as soon as the ramp is clear to do so. Immediately bring the boat over to the trailer and attach the winch line. Bow line and stern lines may be necessary to hold the boat in alignment while it is being winched onto the trailer, if there's any sort of cross wind.

As soon as the boat is cradled on the trailer, lock the winch and pull the trailer clear of the water. Get clear of the ramp area. If you have been boating in salt water, use a fresh water hose, if available, to rinse off the rig. If the wheel hubs have been immersed, pull the caps to see if water is in the hubs. Repack the wheel bearings if necessary; it's better than having them burn out on the highway.

Repack the trailer and car as necessary for the road, and head for home or the next waterway on your itinerary. Once you've mastered the basics of towing, launching, and retrieving, your boating horizon is limited only by the time and finances you have available. If there's a road that leads to the desired waterway, and if there's a ramp at the end of the road, you can go boating. T.B.

See also: BOATING; TRAILERING; TRAILERS, BOAT.

PASSENGER CAR TRAILER TIRES

Tire Size	Ply Rating	Max. Tire Rating	
		Load	Inflation
4.10/3.50-8	4	360	65
4.80/4.00-7	4	520	65
4.80/4.00-8	2	380	30
4.80/4.00-8	4	600	65
4.80/4.00-8	6	725	90
4.80/4.00-9	2	410	30
4.80/4.00-9	4	645	65
4.80/4.00-12	4	790	65
4.80/4.00-12	6	960	90
5.30/4.50-6	2	355	25
5.30/4.50-6	4	565	55
5.30/4.50-7	2	385	25
5.30/4.50-7	4	620	55
5.30/4.50-12	4	915	55
5.70/5.00-8	4	710	50
5.70/5.00-8	6	900	75
5.70/5.00-8	8	1030	95
6.90/6.00-9	4	850	40
6.90/6.00-9	6	1080	60
6.90/6.00-9	10	1450	100
6.90/6.00-12	4	1010	40
6.90/6.00-12	6	1290	60
7.50-10	10	1780	75
9.00-10	10	2200	65

The above includes boat, baggage and special type.

⚠ *Tire pressure is extremely critical and the correct pressure should be maintained. Check pressures when the tires are cold, not after the rig has been on the road for a time.*

Keep Yourself and Your Family Safe from Drowning

Few drownings are unavoidable. Good safety habits and common sense can prevent drownings, and even after a victim is in the water, there are safe, sure ways to assist him

Few of the 7000 or so drownings that occur in the United States each year are unavoidable. Most are caused by ignorance of good safety practices or by carelessness.

There are many steps you can take to protect yourself and your family from drowning. The most basic, of course, is to know how to swim and make sure others in your family do, too. Most drowning victims are either non-swimmers or novice swimmers.

If you own a pond or a backyard pool, read the accompanying safety rules developed by the American Red Cross. Also read the rules for personal safety while swimming and the safety rules for beaches.

In addition, equip your pool or pond with safety gear. The cost is minimal and the equipment is as valuable as life itself.

The Red Cross recommends a safety post. This simple, easy to build life saver comprises no more than a post erected near the edge of pool or pond. On it are a long pole and an inflated inner tube with a length of line attached. At the top of the pole is a can with rescue instructions attached to it, although the use of the pole and inner tube are almost self-evident. The pole can be extended to a swimmer in trouble and the inner tube can be thrown to him.

If the safety post is at a pond that is also used for skating in winter, leave a ladder there as well. If a skater falls through the ice, the best way to reach him is on a ladder layed flat on the frozen surface. It will keep the rescuer from joining the victim in icy water.

Most drownings occur within a few feet of safety. This seems surprising at first, but actually, only about 40 percent of the drownings happen to people who are swimming or playing in the water. Most victims are those who got in the water accidentally, by falling from a dock or boat, for example.

If you see someone struggling in the water, don't be a hero. Suppress that urge to plunge in and tow the victim to shore. Don't let the water claim two victims instead of one.

Think first, then act. If the victim is within arms reach, lie on the deck of the pool or on the shore. Get a firm grip on something sturdy with one arm, if you can, and extend the other arm to the victim.

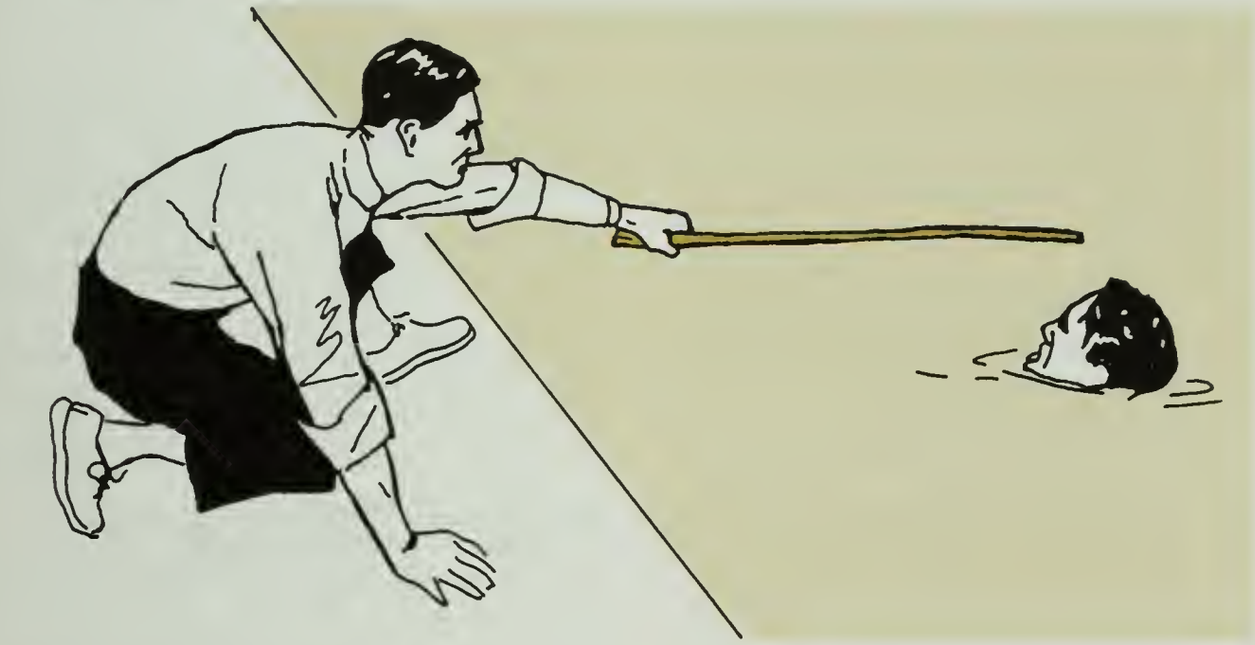
safe wire indicator: see wiring, electrical
sailboat: see land sailer

Grab his wrist or arm and draw him slowly to safety.

If the victim is too far to grasp, extend your reach with a pole, or a tree branch, an oar, or a stick, anything long that the victim can grasp. Take off your shirt, or belt, for example, hold one end and flip the other end out to the victim.

Whatever you use, make sure the victim has a good grip then pull him slowly to safety. Do not let the victim pull you into the water.

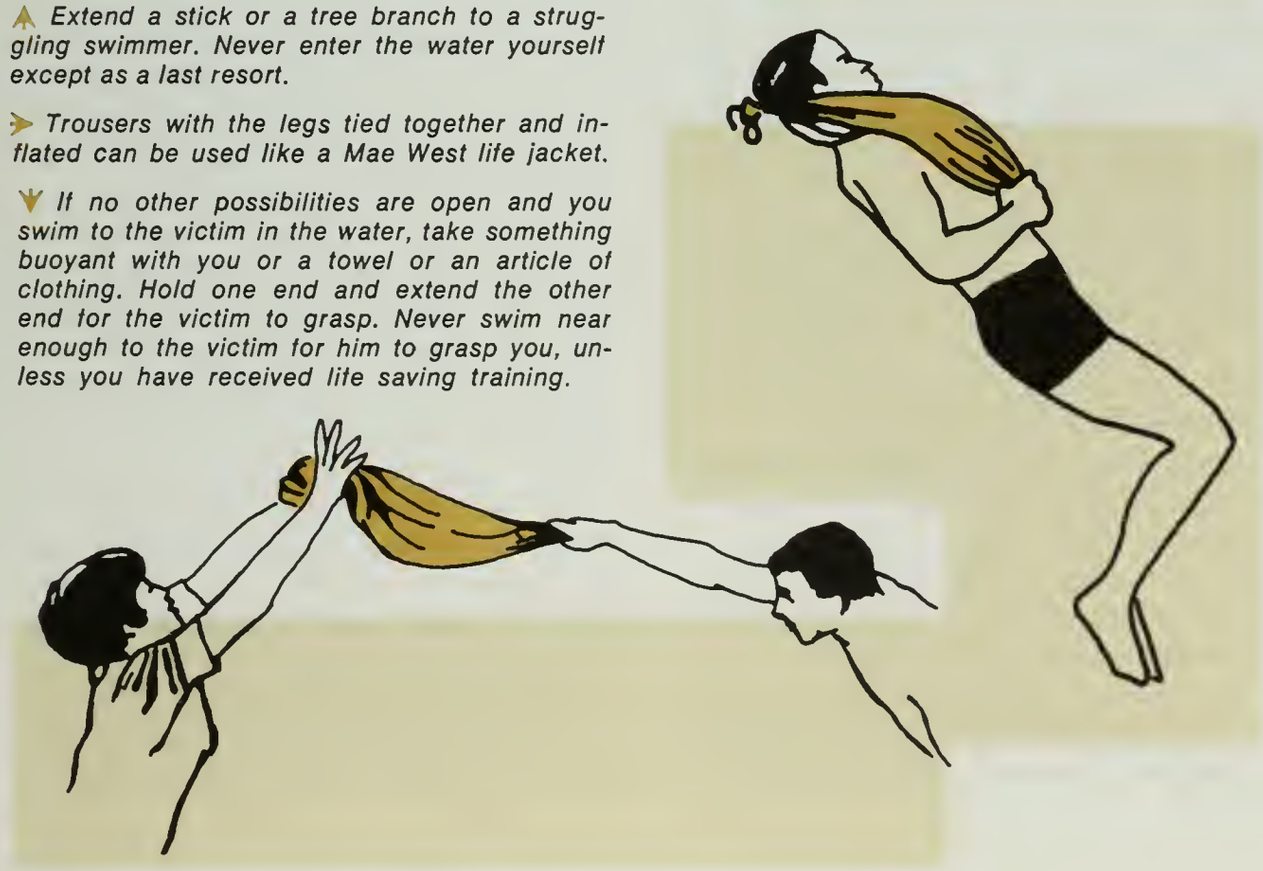
The best way to aid a victim who is beyond range of a pole or stick is to throw something buoyant to him. A ring buoy with a line attached is ideal for this purpose. If there is none, try an inner tube or child's float, or a spare tire from a car; or a



▲ *Extend a stick or a tree branch to a struggling swimmer. Never enter the water yourself except as a last resort.*

➤ *Trousers with the legs tied together and inflated can be used like a Mae West life jacket.*

▼ *If no other possibilities are open and you swim to the victim in the water, take something buoyant with you or a towel or an article of clothing. Hold one end and extend the other end for the victim to grasp. Never swim near enough to the victim for him to grasp you, unless you have received life saving training.*



buoyant boat cushion. If you are on a picnic, a plastic jug will help. Empty it, reseal it and toss it to the victim.

Is the victim beyond throwing range, or is there nothing to throw? Don't jump in yet. Look for a boat, or a canoe, anything in which you can get to the victim without entering the water yourself.

If you do have a boat, paddle or row to the victim, but do not lean over the side to aid him. Let him grasp the oar, then gradually pull him around to the stern.

Do not attempt to haul the victim into the boat. With an overturned craft, you are an additional victim rather than a rescuer. Let the victim grasp the stern. Hold him there yourself if he requires it and wait for help. If the victim is strong enough to maintain a grip on the stern, start rowing and tow him very slowly to safety.

A person, even a good swimmer, who is untrained in life saving should enter the water to aid a victim only as a last resort. Exhaust all other possibilities first.

If you decide to swim to a victim, take a buoyant object with you if you can, or a loose towel or a shirt or pair of trousers. When you reach the victim, extend the object and let him grasp it as you tow him to shore. Do not come within grasping distance of the victim yourself, unless you have been trained to do so.

If you are a swimmer and are yourself confronted with an emergency there are three basic guides for your own safety: do not panic, think and save your strength. There is no quicker way to drown than to thrash around needlessly in the water.

Cramps once had an ominous reputation among swimmers, but actually they can be dealt with easily. Most cramps are of the fingers, toes, arms, or legs. They are caused by over-exertion and are of little real danger unless they cause you to panic.

If you change stroke and relax, chances are the cramp will abate. If it continues, rubbing and kneading the affected muscle may help. An even greater help is stretching the muscle. As soon as you feel a distinct twitch or other sign that a cramp is on the way, change strokes. The cramp may never even arrive.

Stomach, or abdominal, cramps are relatively rare and not as dangerous to swimmers as they were once thought to be.

If it happens to you, relax, stretch and change body position. This will keep you afloat until the cramp passes.

Currents in the rivers or undertows, rips and runouts at an ocean beach can pose difficulties even for strong swimmers. Handle these by swimming across the current rather than attempting to swim against it. Once you are out of it, you can head for shore.

When caught in weeds, move gradually and deliberately to avoid getting entangled. Rather than, quick, vigorous movements, use a slow arm motion with just a gentle waving motion of the legs.

Falling into the water with your clothes on can be dangerous. Clothes hamper swimming efficiency and you need to know how to remove them in the water, although in some circumstances, you may not want to—when, for example, you are very close to safety or if the water is extremely cold and delay might threaten you with exposure, or if you are clinging to a buoyant object.

At times, clothes in the water can be an asset. Trousers and shirts can be inflated easily to support you.

Shoes, however, should be removed and abandoned. They are heavy and impede your kick. Just take a deep breath and assume a jelly-fish-like floating position with arms and legs dangling and head down. Use both hands to remove one shoe at a time, lifting the head from the water to take a breath whenever necessary.

Instead of removing your shirt, inflate it. The closely woven fabric of most shirts and trousers will hold air fairly well when wet.

RULES FOR PERSONAL SAFETY WHILE SWIMMING

1. Learn to swim well enough to survive in an emergency.
2. Never swim alone and swim only with a buddy who has the ability to help when necessary.
3. Swim only in supervised areas.
4. Follow rules set up for the particular pool, beach, or waterfront where you are swimming.
5. Learn the simple and safe reaching rescues.
6. Know how to administer artificial resuscitation.
7. Know your limitations and do not overestimate your ability.
8. Stay out of the water when overheated and immediately after eating.
9. Stay out of the water during electrical storms.
10. Dive only into known waters of sufficient depth.
11. Do not substitute inflated tubes, air mattresses, or other artificial supports for swimming ability.
12. Always swim a safe distance away from diving boards and platforms.
13. Avoid long periods of immersion and overexposure to the sun.
14. Take instruction under qualified instructors before participating in such aquatic sports as skin and scuba diving and water skiing.
15. Call for help only when you really need it.

RULES FOR SAFETY AT THE BEACH

1. Swim in areas supervised by a lifeguard.
2. Never swim alone.
3. Check with a lifeguard regarding beach and surf conditions before swimming.
4. Report any unsafe beach condition to the lifeguard.
5. If you are being pulled offshore by a rip current, do not panic and do not try to buck the current. Swim parallel to shore across the current and, once free, then swim to shore.
6. Call or wave for help if unable to swim out of a strong current.
7. Never fake trouble or calls for help.
8. Never substitute the use of floating devices for swimming ability.
9. Do not use breakable objects on the beach, and, if any are found, pick them up and dispose of them for your own protection and the safety of others.
10. Do not dive into unknown water or into shallow-breaking waves.
11. Do not overestimate your ability by attempting long-distance swims. Swimming parallel to shore is safer and just as much exercise.
12. Continue supervision of small children even where there are lifeguards.
13. Do not swim close to piers or pilings.
14. Avoid sand throwing or any kind of horseplay.
15. Do not engage in unnecessary conversation with a lifeguard.
16. Observe applicable personal safety rules, such as not swimming immediately after eating or when overheated or during an electrical storm.
17. Respect the judgment and experience of the trained lifeguards, follow their advice, and do not interfere with the performance of their duty.

To inflate your shirt, button it all the way to the top and tie the tails together tightly at the waist. Then bend your head into the water, pull the shirt front to your face and blow air into the shirt between the second and third buttons. The air will rise and form a bubble on your back that will help keep you afloat. You may have to hold the collar tightly around the neck. The shirt may lose air, but at a very slow rate, and you can replenish it from time to time.

Trousers also can be inflated. Assume a jelly-fish position and slowly and carefully loosen the belt—do not remove it entirely—and take off your trousers one leg at a time, raising your head to take a breath whenever necessary.

After the trousers are off, tread water and either tie the legs together at the cuffs or tie a knot in each leg as close to the cuff as you can. With the zipper closed, grasp the trousers at the back of the waistband, holding them just beneath the surface, and splash air into the waist with the free hand. Just strike downward with the palm, following through to a point just inside the open waist.

An alternate method of inflation is to raise the head and take a breath, then submerge the head and expel the air into the waistband.

The waist of the inflated trousers should be gathered together with the hands or by tightening the belt. Slip your head between the tied trouser legs and pull downward so the cuffs are behind your neck and you are holding the waist of the trousers at about your own waist. If the legs are knotted at each cuff rather than tied together, simply use the trousers as you would water wings.

Another recommended standby for swimmers is the survival floating method adapted by the Red Cross from the drownproofing technique developed by a swimming coach. This method is designed to keep a swimmer afloat for long periods with a minimum expenditure of energy.

Start with lungs full of air. Float with

SAFETY RULES FOR PRIVATE POOLS

1. Never permit anyone to swim alone. Constant and responsible supervision is a must. No child should be left unattended in the pool area even for the length of time it takes to answer a telephone.
2. Have adequate fencing and a gate with a lock to prevent children from unauthorized entry.
3. Keep basic rescue and lifesaving equipment always available.
4. Post emergency instructions and telephone numbers conspicuously.
5. Have an adequate first aid kit available.
6. Enforce common sense safety rules at all times. At least one responsible person should know how to administer artificial respiration and give intelligent first aid.
7. Clearly mark the deep and shallow sections. Separate the deep and shallow water by use of a buoyed line whenever weak swimmers or non-swimmers are using the pool.
8. Do not allow running, pushing, or boisterous play on the deck.
9. Encourage responsible parents or other adults to give water safety and swimming instruction to youngsters. (A recommended text is the American Red Cross booklet *Teaching Johnny To Swim.*)
10. Make sure there is adequate filtration to maintain good clarity of the water. Consult the local health department for regulations on pool sanitation.
11. Do not permit bottles, glasses, and sharp objects in or around the pool area.
12. Observe applicable personal safety rules, such as not swimming immediately after eating or when overheated or during an electrical storm; use of inflated objects by non-swimmers; and diving only in known and safe depths.

SAFETY RULES FOR PONDS

1. Never swim alone.

2. Mark off safe swimmig areas with buoyed lines. Remove underwater snags, trash, bottles, and the like.

3. Avoid swimming areas immediately in front of steep-sloping banks.

4. Post warning signs at danger points.

5. Supervise children at *all* times.

6. Have water checked and approved by the local health department and recheck it periodically if used for swimming.

7. If practical, erect an adequate fence and a gate with a lock to prevent unauthorized entry by children.

8. Keep basic rescue and lifesaving equipment always available.

9. Post emergency instructions and telephone numbers.

10. Have an adequate first aid kit available.

11. Enforce common sense safety rules. At least one responsible person should know how to administer artificial respiration, perform basic reaching rescues, and give intelligent first aid.

12. Have a responsible adult start water safety and swimming instruction for potential farm pond users. (A recommended text is the American Red Cross booklet *Teaching Johnny To Swim.)*

13. Make sure that piers, rafts, and landings are well built and securely braced.

14. Observe applicable personal safety rules such as not swimming immediately after eating, when overheated, or during an electrical storm; use of inflated objects by non-swimmers; and diving only in known and safe depths.

15. If pond is used for skating, add a ladder to the safety post as helpful emergency equipment.

16. To avoid accidents on the ice: Never skate alone. Skate only on a safe thickness of ice. Maintain supervision at all times. Skate in a restricted area.

the face down in the water and the arms and legs dangling. The back of the head is at the surface. Rest floating in this position for a few moments.

Maintain body and head position, but slowly and gently, lift your arms to shoulder height. At the same easy pace separate and lift the legs for a gentle scissors kick. Make sure the head is still at the surface. Raise it just enough for the mouth to clear the surface, exhaling at the same time. Keep your eyes open to gauge head and body position.

When the head is vertical, press the arms downward and bring the legs together in a modified scissors kick. This should provide time to breathe in through the mouth. The action of the arms and legs should be strong enough only to keep the mouth out of the water. If your chin rises above the surface you are working too hard.

Complete the cycle by slowly allowing the arms and legs to move to their dangling position and your head to sink forward into the water. If you sink too much, a slight downward thrust with the arms or a very gentle scissors kick should suffice to balance the tendency. Keep repeating this cycle until you are rested or help arrives.

Much additional information on water safety, swimming and life saving is available from the Red Cross, which conducts an intensive water safety campaign and publishes a wealth of material on the subject, some of it free and the balance for sale at nominal cost.

See also: SAFETY, BOAT; SCUBA DIVING; SWIMMING; WATER SKIING.

Sailing for Beginners

Use these fundamentals to get started in a healthful and enjoyable sport

SAILING IS EASY and inexpensive. If you are outdoorsman enough to navigate a power boat, you can skipper a sailing craft. Admittedly, the initial movements are the hardest, but that's because the concept of making way afloat, powered only by the wind, seems strange to a beginner. Like writing a novel or plunging into a mass of income tax forms, the first immersion is without a doubt your greatest shock.

If you are learning aboard an Alcort sailfish, you have one of the simplest of windpowered boats, basically a board fitted with a mast and sail. If you must contend with both a mainsail and jib, using such class craft as a Penquin, Snipe, Blue Jay, etc.—you will need more know-how because the rigging is much more compli-

sailing dinghy: see runabouts
sailing surfboard: see boat building projects
salmon: see fishing
sandbox: see playhouse

cated. Obviously, if there's any choice, you're best off starting with a dinghy and sailing protected waters with a warm sun shining and gentle winds blowing. Ideal sailing conditions will make your first voyage that much easier and your novice mistakes that much less catastrophic.

The mainsail is triangular in shape. In the language of small-boat sailors, its leading edge, attached to the mast, is called the luff. Its bottom edge, attached to the boom, which is the spar extending aft at right angles to the mast, is called the foot. On the hypotenuse of the triangle, the longest or trailing edge of the sail opposite the right angle where the boom and mast are joined is referred to as the leech.

The uppermost corner of this mainsail is its head, the trailing corner the clew, and the lower leading corner, formed at the intersection of mast and boom, the tack. To raise or lower this sail, you pull or release the tension on the halyards; to trim or control the angle at which the sail meets the wind, you adjust it with the sheet.

Now that you've been introduced to some of the basic sailing terminology, which you may use or ignore according to your leanings, it's time to put on or bend the sails in place. If your sailing craft has two sails, start by shackling the jib tack to the deck fitting, snap the jib hooks to the bow stay, and shackle the head to the jib halyard after first looking aloft to make sure this line is clear. If your jib has battens, which are the wooden inserts used to stiffen a sail, place them into their slots and attach the jib sheet to the clew. Now drop the sail to the deck and make sure she doesn't fall overboard, then turn your attention to the mainsail.

It doesn't make much difference whether you attach your mainsail to the boom or the mast first, though old-time sailors will occasionally argue the point. At all events, bend her into position, make sure the rudder is inserted into the brackets attached to the transom for that purpose, lower the centerboard, and you are about ready to get under way.

Probably the most important problem facing a beginner aboard the first sailboat is the determination of winds. You cannot sail successfully unless you know which way the wind is blowing. Look for smoke belching from some factory or house chimney, an ensign blowing on a flagpole or jackstaff, even the way ripples move across an open stretch of water in an exposed area. Look at the clouds scudding overhead. Remember that eddy currents beneath a high rock bluff or wind bouncing off tall buildings, cliffs, houses or even trees can be dangerously deceptive and changeable.

You can tie a telltale or ribbon on one of the shrouds of your boat, as most sailors do, and estimate both wind direction and velocity by the way that piece of cloth waves in the breeze. Obviously, afloat, you should employ more than one of these indicators, placed both port and starboard.

The wind is seldom constant. Every windjammer skipper, as well as navy officers on sailing men-of-war through history, depended on past experience and their weather eye to foresee a gust before it arrived, taking advantage of a shift prior to losing wind on the canvas. With a little familiarity you'll soon pick up the knack of sensing a change when you spot a cloud patch moving swiftly, or when dark patches of water or increased whitecaps over one section of the sea begin heading ominously in your direction.

Your boat moves forward when the wind fills the sail and drives her. Unless you have a centerboard or keel extending downward under the hull, you would only be able to proceed down wind. By using this underwater obstruction, usually an adjustable centerboard, you are able to point her one way or the other and take advantage of the forward thrust while countering that force

exerted sideways. As evidence of this, forget to lower your centerboard just once. The boat will be virtually unmanageable as well as tippy.

A zigzag course. You can't proceed to a point directly to windward; you must trace a zigzag course, tacking one way and then the other to reach your objective. If you did point the rudder directly to windward, you'd discover your sails flapping uselessly, fluttering, or luffing. Sometimes you'll deliberately luff a sailboat to lose forward momentum prior to executing a maneuver, thus spilling the wind instead of utilizing it. It's a variety of safety valve since an overpowered sailboat, heeling so far she's in danger of capsizing, can quickly be brought back to an even keel by releasing the mainsheet to decrease the wind pressure, by shifting your weight to windward to balance her, or by letting the sail luff by turning the rudder into the wind.

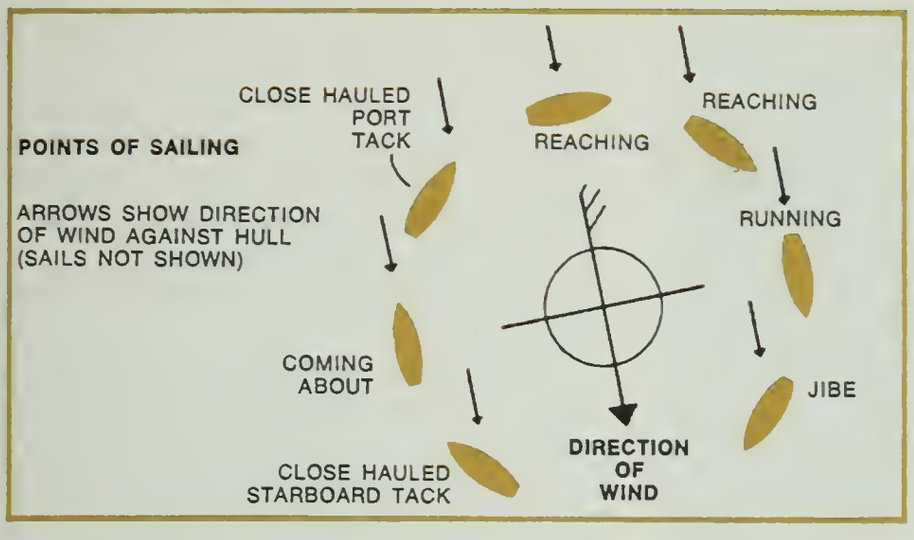
If you were to sail your sloop or dinghy in a complete circle, you'd be close-hauled on the starboard tack when the wind is coming over the right side of the boat, facing the bow, with the mainsail trimmed in tight and heading approximately 45 degrees off the wind. As you head into the wind, your sails luff. When they fill again, with the wind now coming over the left or port side of the boat, you are close-hauled on the port tack. As you head farther off the wind, easing your mainsheet until the breeze hits your sail nearly perpendicular, you are reaching. A close-reach is anything less than broadside to the wind, a beam-reach is broadside, and a broad-reach is anything more than broadside but less than the wind directly over your stern. When she comes huffing in over the transom, you are running free or sailing before the wind.

Tacking is simply changing the direction that the wind hits your sail, letting it come either over the port or starboard side, luffing momentarily as you execute the maneuver. If you tack while headed with your bow into the wind, it's called coming-about. If you tack with your stern exposed, you are jibing. You must come-about with your centerboard all the way down; you can get away with the board halfway or even fully raised on a broad-reach or running free in reasonably light winds. When she's down, she bites and prevents you from slipping sideways. When she's up, it reduces water friction and permits you to make increased speed.

A good sailor is smooth and fluid during the execution of any of these maneuvers. By reasoning out what is going to happen before the wind takes effect, the skipper is able to control the craft and give direct, non-contradictory orders to the crew.

Suppose you want to change your bow heading from one point of sailing to another, changing tacks by coming-about. On a sloop-rigged craft, you must warn the crew by telling them, "Ready about." They will thus be prepared to tend the jib and the mainsail sheets as well as shift their weight to correct the trim when the wind switches sides. On a dinghy, it's still necessary to warn your passengers before maneuvering lest the changeover dump you all in the water.

The boat should be going through the water with a reasonable amount of speed. Shout "Come about" or "Hard-a-lee" as you start into the turn, pushing the tiller to leeward or toward the sail so that the bow turns into the wind. Momentarily, she will luff, the sails fluttering. As the bow swings about 45 degrees across the wind, the sails will fill again, the boom swinging across the cockpit. Skipper and crew should shift from one side of the cockpit to the other as the action takes place and be settled to windward before the sail is full. The tiller should be brought back amidships and steadied there. Whoever is tending jib should have released the windward jib sheet as you started into the turn, now trimming the leeward sheet as she fills.



Wind direction determines the angle at which you should position your main boom for maximum speed.

Jibing is the opposite of coming-about, the wind now coming over the stern. The bow of the boat is turned away from the wind instead of into it, the sails staying full to the last second instead of luffing. They fill instantly on the new tack with a smashing motion that can cause disaster if it is not controlled. You should learn to jibe only in very light winds for safety. You should be in complete control of your boat with a measure of experience under your belt before calling out the orders "Ready to jibe" and "Jibe ho."

Turn your boat so that her bow crosses the wind direction while running-free. As soon as the breeze catches the other side of the mainsail, stop the turn and allow the sheet to pay off quickly until the boom is all the way out. On a sloop-rigged boat, release the jib sheet and trim her from the other side.

When you're headed home, approaching an anchorage or mooring, you want to stop all forward motion and let the boat coast into the desired spot. To do this, you luff your sails and let them flutter. The boat comes to a halt. Technically, if your timing is exact and your seaman's eye accurate, you or your crew should be able to reach over the side and grasp the mooring ring or the dock. In practice, if you're a trifle off, the sailboat will either slip backwards, "in irons," or she'll overshoot the mark. In either case, there's nothing to be done except try it again until you make a better connection.

Before you leave the dock, check your life preservers and make sure all loose gear aboard is secured. If your centerboard has a plate pin, reinsert it after lowering the board as a security measure. In the first stages of a capsize, try to move rapidly to the upper side of the boat to minimize the amount of water flooding into the cockpit. *Never leave the boat!* Right her if possible, but stay with her until help arrives. It is entirely possible that your life may depend on that simple rule. C.R.M.

See also: BOATING; LAND SAILER; NAVIGATION; SAFETY, BOAT; SAFETY, WATER; TRAINING BOAT.

GLOSSARY OF SAILING TERMS

Abeam. At right angles to the boat's bow-to-stern centerline, off to one side or the other.

About. Sailboats come about when they are steered across the wind so the wind switches from one side of the sails to the other.

Batten. A strip of wood placed in a pocket in the sail to maintain its shape and sometimes to stiffen it.

Boom. The horizontal spar to which the bottom edge of a sail is connected.

Bow. The front portion of a boat.

Centerboard. A plate of wood or metal that can be lowered or raised above the boat's keel, used to prevent the hull from being shoved sideways by the wind.

Clew. Portion of sail at rear lower corner.

Cockpit. The opening in a boat's hull in which the crew sits.

Eye of the wind. Directly in the direction the breeze is coming from.

Head. The upper point of a triangular sail and the bathroom aboard.

Helm. Wheel or tiller controlling the rudder.

Irons. When the sails remain flapping and you haven't enough momentum to come about and start sailing in the opposite direction, when you're sort of stuck and appear not able to make progress in a maneuver.

Jib. The triangular small sail placed forward of the mainsail.

Jibe. Sailing with the wind astern so that the breeze switches from one side of the sails to the other, passing through the eye of the wind with the stern of your boat to it.

Keel. The lengthwise timber along the bottom of your boat from bow to stern.

Leeward. The side of the boat opposite to that of the wind's direction, the lee side.

Leech. The back or after edge of a sail.

Lines. The various ropes used in handling your boat.

Luff. Both the forward edge of a sail and the action of steering directly into the direction the wind is coming from so that the sails flap aimlessly without exerting forward pulling power.

Port. The left side facing the bow of a boat.

Rigging. All the gear and equipment used to support and control the sails aboard.

Running. Sailing with the wind coming over your stern or from that general direction.

Sheets. Lines used to control the angles at which sails are set in relation to the wind.

Shrouds. Usually made of wire, the rigging running from the masthead to the sides of a boat to support the mast.

Starboard. The right side of the boat as you face the bow.

Stern. The extreme back end of your boat.

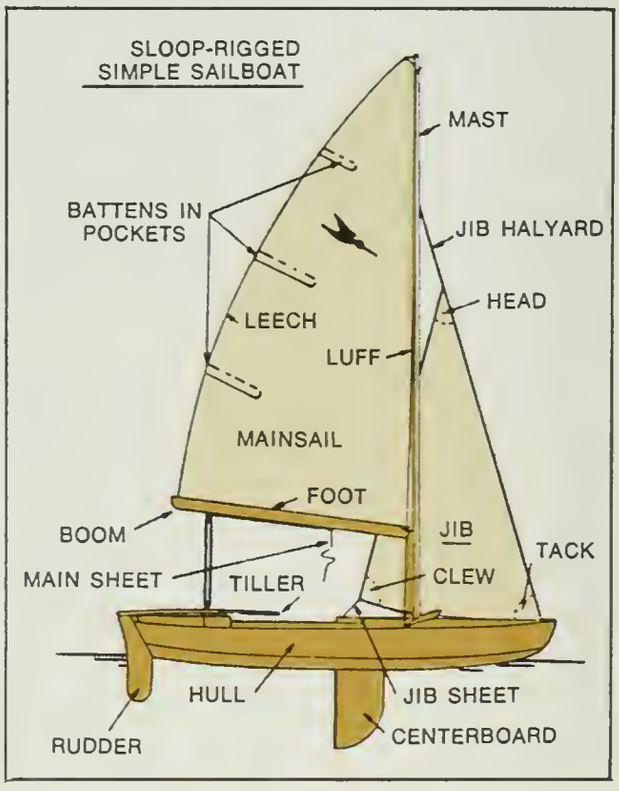
Tack. Both the lower forward corner of a sail and the maneuver in sailing where you make progress in a windward direction by alternately sailing with the wind on one side of the sails and then on the other, a zigzag course towards the eye of the wind.

Tiller. A device operating the rudder on boats not having a wheel.

Transom. The piece on the extreme rear or stern of your boat.

Underway. Meaning you are progressing in a desired direction, actually on course.

Windward. The side of the boat from which the wind is blowing, as opposed to leeward.



➤ *Learning some simple names is an important part of understanding and enjoying the sport.*

How to Use a Pad Sander

Save yourself hours of arm-tiring labor with this useful tool, whether you are finishing fine woodwork or merely polishing the family automobile

Even curved pieces can be sanded quickly and easily by using the toe of the sander.

THERE ARE MANY GOOD reasons why you should consider the purchase of a finishing pad sander, similar to the one shown here, even if you already own a belt or disk sander. A pad sander does not produce the troublesome swirl marks characteristic of disk sander action; and because it is slower cutting than a belt sander, it can be controlled more easily to produce really fine wood finishing jobs. The pad sander can save you hours of time by making many other around-the-house chores easier to do. It can be used to remove old paint and varnish before refinishing, for smoothing out spackle used to patch holes in walls, buffing the wax applied to the family car or to furniture, and even for polishing small metal and plastic objects.

The most popular type of pad sander features a rotary motor that imparts an orbital motion to the sandpaper attached to the platen of the sander. The orbit may be circular or elliptical, but in either case the orbit is so small that you cannot see it in action. Orbital action removes wood much faster than linear (straight back-and-forth) action that is typical of a second, less expensive breed of pad sander that utilizes a magnetic vibrator to drive the platen. Some deluxe pad sanders provide both orbital and linear sanding at the flick of a switch. If you are interested in ultra-fine finishing of good furniture, the extra cost of such a combination job may be justified; but for the average homeowner and craftsman, the orbital sander alone is sufficient.

Basic sanding procedures. Although many pad sanders have grips for two-handed operation, do not assume that this is because pressure must be applied. In fact, a pad sander works most efficiently if you apply no more pressure than that provided by the weight of the machine; use your hands simply to guide the machine over the work.

If your sander is double-insulated, it can be safely plugged into any wall socket that provides proper AC voltage. If the sander is not double-insulated, it should have a three conductor cord terminating in a three-pronged grounding plug. Use the grounded plug only in a suitable, properly grounded socket to ensure your personal safety. If

sanding: see finishing, wood
sanding disc: see drill attachments, power
sanding drum: see lathe
sandpaper: see abrasives

you must use a long extension cord, select one having No. 18 A.W.G. (American Wire Gage) or larger conductors for distances up to 100 feet. If the wire is too lightweight, there may be enough of a voltage drop to damage the sander motor.

Most pad sanders utilize strips of sandpaper measuring about 3⅔ x 9 inches which you can obtain by cutting (don't tear) a conventional sheet of sandpaper into three equal parts. Clips at the front and rear of the platen hold the sandpaper in place, over the sander pad. Stretch the sandpaper as tightly as possible before fastening under the second clip because loosely attached sandpaper will not perform efficiently. Start the sander and let it get up to proper speed before laying it down on your work, move it about slowly and evenly in overlapping arcs, and remove from the work before shutting off the motor.

Actually, no special skill is required to use a pad sander. You will get the hang of it within a minute or two after you first turn it on. But you won't obtain the best possible performance from the sander unless you become familiar with the various types of sandpapers that are available, and what they are used for. No one type or grade of sandpaper can possibly handle all your sanding jobs, and buying all available types and grades would be a waste of money.

Choosing the right sandpaper. You can scratch one type of sandpaper off your list immediately, as far as its use with any mechanical sander is concerned; it's the old-fashioned flint sandpaper having granules of quartz as the abrasive material. Flint sandpaper simply is not strong enough for machine use. This leaves you with three other basic types of sandpapers: garnet, aluminum oxide and silicon carbide. In many instances their uses overlap, but not necessarily in reverse order. For example, you could use aluminum oxide papers for those jobs that a garnet paper could handle easily, but the garnet paper cannot equally well substitute for the aluminum oxide paper when the job calls for more abrasive toughness than is characteristic of garnet.

Aluminum oxide is a synthetic material that is somewhat harder and tougher than garnet, and significantly tougher than flint. But the slightly higher price of aluminum oxide paper is more than offset by the longer use you will get from it. Aluminum oxide paper is unquestionably the favorite among home craftsmen.

Garnet is superior to flint, but it is losing out to aluminum oxide so you may not even find it in all stores. If you do, and the price is right, it will serve very well for ordinary woodworking.

Silicon carbide is a very hard synthetic mineral (almost as hard as diamond) so it can tackle really tough jobs. It is usually applied to cloth or waterproof paper backings so that it can be wet with water or light oil for final smoothing and polishing operations. You are likely to see silicon carbide papers only in the finer grits. Both silicon carbide and aluminum oxide papers are suitable for working metal as well as wood.

The abrasive characteristics of sandpapers are rated in several different ways, but the two most common systems utilize grit numbers and/or a numerical grading scale. Grit numbers run from about 16 (very coarse) to 400 (very fine). The finer the particle, the larger is the grit number which actually indicates the number of openings per square inch of screening through which the abrasive particles could pass. The numerical system works just the opposite; the smaller the number, the finer the grit size. In fact, the industry soon ran out of real numbers and had to go to a multiple zero numbering system as finer grades of sandpaper were developed. For example, grade 4 paper is very coarse; the coarsest coarse paper is number 2; the coarsest medium paper is 1/2; the coarsest fine paper is 3/0 (an abbreviation of 000); and the

coarsest very fine paper is 6/0 while the finest very fine paper is 10/0.

As a general rule, you should use a slightly coarser sandpaper on hardwoods to obtain the same degree of smoothness you could get on softwood with a slightly finer sandpaper. Use the coarsest sandpapers only for roughing which implies the removal of a considerable amount of wood. A medium grit paper should be used for blending which involves some material removal and the imparting of a fairly smooth finish. Fine sandpapers are used primarily to eliminate fine scratches made by coarser sandpapers. Very fine grits are used for final polishing and rubbing actions.

To start, you should try out the effects of the various grades of sandpaper (very coarse, coarse, medium and fine) on both soft and hardwoods. But do not buy every grade within these basic categories until you see a specific need; and you would probably waste your money buying very fine sandpaper unless you are involved in a finishing project that calls for extremely fine finishing. To get you thinking in the right direction, not only in the selection of papers for woodworking but for other applications such as processing of metals and plastics, here is a summary of the recommendations made by the manufacturer of the pad sander illustrated.

Soft wood and wallboard. Use 2-1 grit garnet cabinet paper for fast material removal, 1/2-2/0 garnet for material removal with fair finish, and 3/0-5/0 garnet finishing paper for fine finish. Aluminum oxide papers of comparable grits can be used, but the toughness of aluminum oxide is not actually required when working with such soft materials.

Plastics. 60-100 grit aluminum oxide for material removal, 120-220 silicon carbide wet paper "C" weight for material removal with fair finish, and 240-600 silicon carbide wet paper "A" weight for fine finish.

Hardwoods and hard composition mate-

▲ *Three basic steps of wood finishing involve preliminary sanding with progressively finer grades of sandpaper, raising the wood fibers by sponging with water and sanding off the raised fibers for a final smooth finish.*

rials. 36-50 grit aluminum oxide for material removal, 60-100 grit aluminum oxide for material removal and fair finish, and 120-180 aluminum oxide finishing paper for fine finish.

Soft metals. 36-60 grit aluminum oxide metal working cloth for material removal, 80-120 aluminum oxide cabinet paper for material removal and fair finish, and 150-320 silicon carbide wet paper for fine finish.

Hard metals. 40-60 aluminum oxide metal working cloth for material removal, 80-120 aluminum oxide metal working cloth for material removal and fair finish, and 150-320 (or crocus) aluminum oxide metal working cloth in oil for fine finish.

Hard brittle minerals and compositions. 50-80 grit aluminum oxide for material removal, 100-180 aluminum oxide finishing paper for material removal and fair finish, and 220-320 silicon carbide wet paper "A" weight for fine finish.

Hard tough minerals and compositions. Aluminum oxide metal working cloth for material removal, 80-120 aluminum oxide metal working cloth for material removal and fair finish, and 150-320 aluminum oxide finishing paper for fine finish.

Paints and varnishes. 2½-1½ open coat garnet cabinet paper for material removal, 240-400 silicon carbide wet paper "A" weight for fine finish.

When walls need redecoration, spackled holes and other bumpy areas can be smoothed down to perfection, quickly and easily, with light-weight orbital sander.

Sander fitted with fine grade sandpaper can be used to finish the edges of plastic sheets, and to produce "ground-glass" effects as shown.

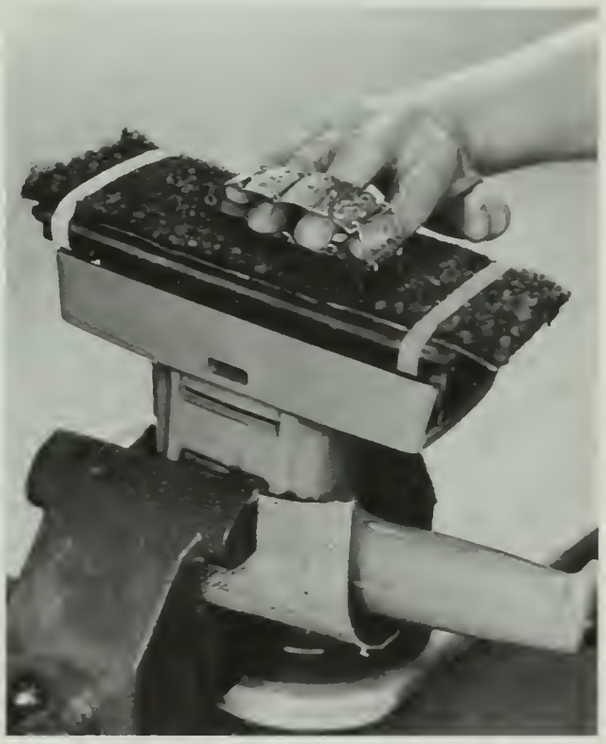
Fine finishing techniques. If you want the best possible finish on your woodworking projects, you must follow specific surface preparation procedures. Hasty or inexpert use of a sanding machine will lead to disappointment, in which case you should not be too ready to blame the equipment. Good finishing, even when using time- and labor-saving machines, requires patience.

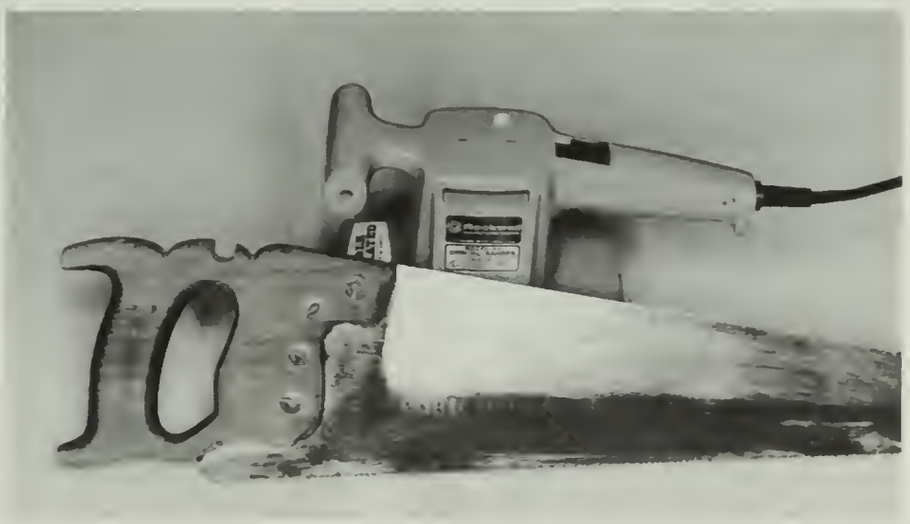
The wood should first be sanded down to the smoothest and flattest possible surface using various selected grades of sandpaper. Do not jump from a coarse to a fine sandpaper and expect good results; prepare the surface in stages until you have the kind of smooth finish you want.

When working with hardwoods, you can obtain noticeable improvement in the surface as you go to finer grits, all the way down to a 9/0 paper. But such very fine pa-

Buffing car wax is no longer an arm-breaking job. Fit lamb's wool pad on sander and let it drift over the car surface without applying pressure.

Jewelry and other objects can be buffed on sander that has been clamped into a vise. Note scrap of carpeting used to protect sander from vise jaw. Do not clamp so tightly as to crack the sander's plastic casing.





Badly rusted and otherwise corroded tools can be salvaged by sanding with fine sandpaper. Bright area on this decrepit old saw was produced in very short order by sander's orbital action.

per would be wasted on softwood which just won't sand down to a comparable surface. About the finest sandpaper that is practical for softwood is a 6/0 paper. Also, it is rather pointless to work toward an ultra-smooth surface if you plan to apply an enamel coating which would fill in minor pores anyway. A 4/0 or 6/0 paper should be fine enough to prepare a wood surface for enameling.

If you intend to apply a clear type coating, and especially if the wood is to be stained with a water stain, the sanded surface should be wet down with clear, warm water. This makes the wood swell and raises fine surface fibers so that they can be re-

moved with a final sanding, using the finest sandpaper used in the preliminary sanding, *after* the wood has dried thoroughly, preferably by standing overnight. Do not skip this step if you are to use water stains. Some workers go one step further and apply a coat of thin shellac or a special sanding sealer after the fibers have been raised to harden them before the final sanding; this produces an even smoother final finish. Just be sure not to apply a sealer that might prevent a stain from being absorbed properly by the wood.

These tips provide only the rudiments of good finishing practice, and will be quite adequate for many average wood-finishing jobs. But if you plan to do very exacting finishing, or re-finishing of fine furniture, you should refer to books that deal with such subjects in detail. There are many special tricks and techniques you should learn before attempting serious finishing work.

Other applications. Your pad sander can be used for many purposes other than the basic job of preparing wood for finishing. An orbital sander will do a good job removing old paint and varnish provided that you pick the right kind of sandpaper. Ordinary closed coat sandpapers will soon clog up and become useless; what you need is a special "open coat" abrasive having the grit particles spaced relatively far apart so that they do not clog as easily. It's also important to keep the sander moving constantly with broad, sweeping motions. If you stay in one place too long, the paint or varnish may become soft and gummy because of the frictional heating. If you use a liquid paint or varnish remover to speed the job, let the solvent dry completely before using your pad sander. In all such removal jobs, the loose paint or varnish should be scraped off with a putty knife before the sander is used, to make the sandpaper last longer.

The taped joints and spackled nail head indentations in a new gypsum wall can be smoothed quickly and easily with your pad sander by using a fine grit, open coat abrasive. Similarly, it's a cinch to repair cracks and nail holes (as from old picture hooks) in existing walls by spackling and then sanding smooth with the pad sander. Caution: plaster dust is very abrasive, so do not let it accumulate on or inside your sander; use compressed air (vacuum cleaner) to blow the dust off frequently.

When polishing and smoothing such materials as plastics and metals, it may be desirable to lubricate the sandpaper with water, soluble oil or some other nonflammable material, depending on the nature of the project. *Never* use an inflammable liquid such as benzine, naphtha, or gasoline because the fumes could be ignited by sparks inside the sander. While some sanding techniques can be used to smooth plastic, there are ways to roughen plastic surfaces for desired decorative effect. For example, the surface of acrylic plastic sheet can be quickly changed to a fine ground glass effect by sanding with fine, dry sandpaper.

You will find many other practical uses for your pad sander around the house. Buffing the wax on your car is a cinch if you add a lamb's wool pad to your sander. Mount the sander upside down in a vise and use it to buff and polish all sorts of small objects, such as metal jewelry. Experiment with different types of buffing pads, from thin cloth to scraps of carpeting. The use of buffing compound may help the process. The sander is also excellent for tough rust removal jobs. Just go over that decrepit old saw, or other tool, with your sander after fitting it with fine sandpaper. You may be surprised at the big improvement.

Undoubtedly, you will think of still more uses for this versatile tool if you experiment with it. J.H.

See also: ABRASIVES; FINISHING, WOOD; PAINTING; PAINTING, AUTO; POWER TOOLS; WOODWORKING.

Install a Sauna Bath in Your Home

You can enjoy the pleasure and health of a sauna in your own house at less cost than you might think. It's relatively simple to build and the only special equipment required is the heater

WHICH WOULD YOU RATHER have: a swimming pool or a sauna? If you are a bona fide Finn, the odds are that you will first pick the sauna. The correct pronounciation, by the way, is "sow-na." The first syllable rhymes with "now," rather than "saw." If you are an American who doesn't have the money or space for a swimming pool, you can afford a sauna and you probably have all the space you need for it. What's more, if you live in northern climes, you can enjoy your sauna the year around instead of just during the brief summer period when a pool is useful. Finally, if you are blessed with a budget that doesn't need close watching, you will first build the swimming pool and then add a sauna building at poolside. This is a natural combination that couldn't be beat.

Building a sauna is a good project for the handyman. There's really nothing very tricky about it, especially because electrically-powered sauna heaters are now available from several suppliers; they come in a variety of sizes, so there's one to fit virtually any need.

First, let's clear up a couple of prevalent misconceptions about the sauna. First, the sauna is not a steambath in the same sense as a Turkish bath, although the Finnish sauna has often been called a steambath (which it is, but in a rather different way). Essentially, the sauna is a very hot room where, most of the time, the humidity is kept very low. And for good reason. You can stand temperatures from 150° to 200°, enjoyably, if the humidity is kept way down

Heavy insulation is a must in sauna construction, whether you build your own or have one installed.

Basically, the sauna is designed to supply dry heat, but a little steam can be pleasant. Pour a little water on the stones of the sauna heater and you'll get a burst of heat, but not the mugginess of a Turkish bath.

around 5- or 10-percent. The dry heat stimulates profuse perspiration, yet you don't detect any sort of oppressive muggy feeling in the sauna environment. A second related misconception derives from over-emphasis of this dry heat concept. The fact is that a true Finnish sauna is built so that you can increase the humidity at will, by throwing hot water onto rocks heated by the stove or electric heater. If the sauna is very hot to begin with, the steam will not be visible; the "dry" steam, when generated as mentioned, billows up and and comes down around your body like an invisible heat blanket. The Finns call this form of steam "Löyly." (This word is virtually unpronounceable by Americans, even if a Finn is heard to say it; it definitely does *not* rhyme with "doily.")

The one additional misconception you might harbor is that you couldn't possibly withstand, much less enjoy, the high temperatures in a sauna. The fact is that if you are in good health, the odds are that you will not only enjoy the sauna but become addicted to it. Why? Because the tension-easing, tranquilizing effect is something else again. What's more, you will feel clean in a way you wouldn't believe. You can go into a sauna thinking that you are clean. But when the perspiration starts rolling, and you rub your skin with the palm of your hand, don't be surprised if you find visible dirt that has been forced out of the recesses of your skin pores.

Size and location. You can build your sauna almost anywhere in your house, or on your outside property (zoning laws permitting) where there is space. You can buy a pre-built, so-called sauna for a couple of hundred dollars that is hardly larger than a telephone booth. But that is no way to enjoy the full benefits of the sauna; consider such a mini-sauna as a desperation measure only.

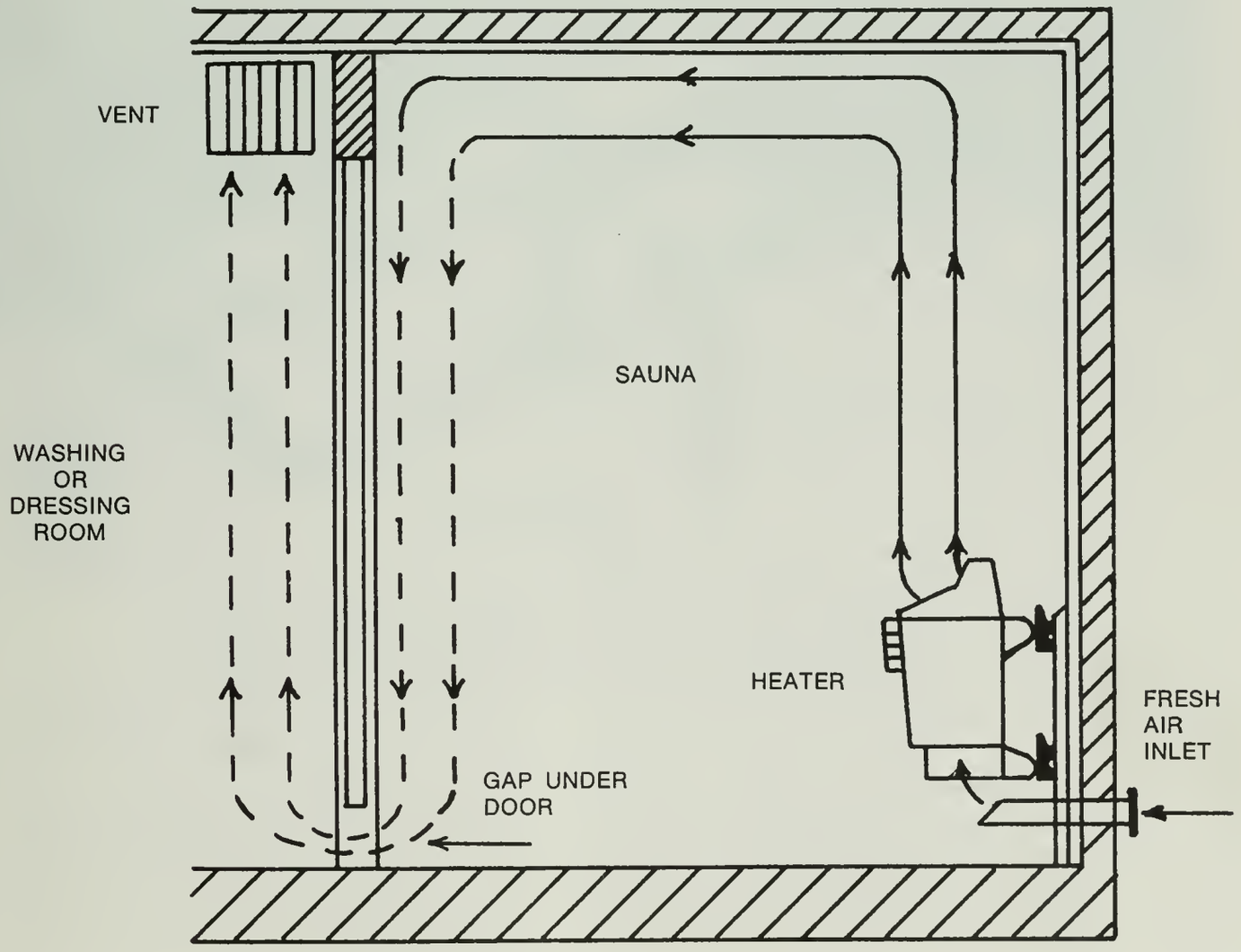
The minimum comfortable sauna is about seven feet square, although you could get by fairly well with one measuring only 4 feet by six or seven feet. The 7 x 7-foot size provides a wall long enough to accept benches on which even tall individuals can lie down in comfort. A sauna that forces you to sit upright, or slouch in a back-breaking position, is at best only half a sauna. There should also be enough extra

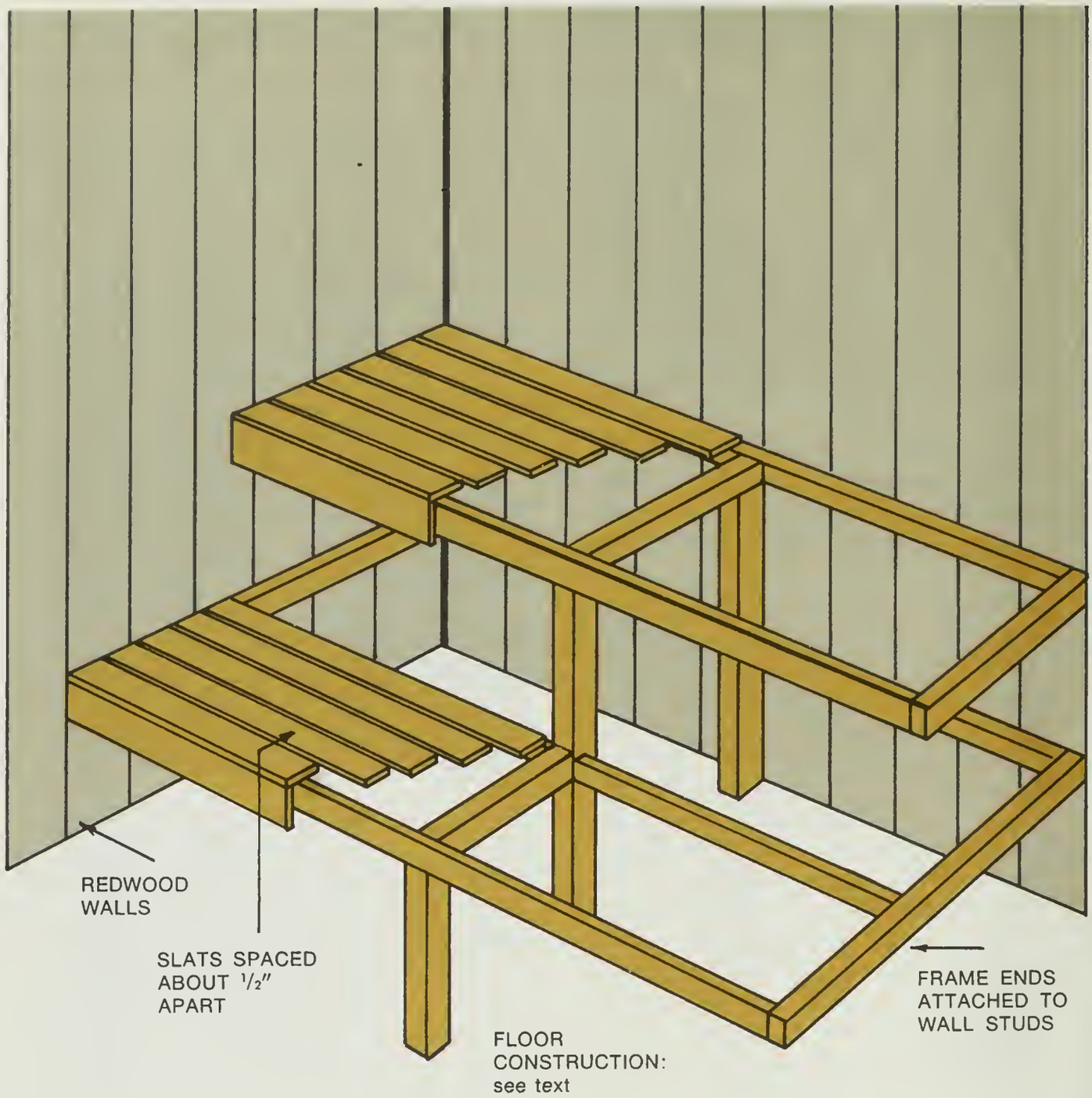
floor space to permit moving about without crowding and bumping into the heater unit.

You can put the sauna in your basement, build it into a walk-in closet just off your bedroom bath, or do as the Finns have always done it—construct a separate building in the rear part of your property, preferably next to a pond or river and in a birch grove (ideal for reasons to be explained). If you opt for an outside building, perhaps next to the swimming pool, make it a two-room affair; one half becomes the heat room, the other a dressing room.

Incidentally, you will often see sauna plans in which the heat room is separate from the washroom. This is not at all necessary, but it can be convenient if space permits. The fact is that you can take heat and wash in the same room if it is properly constructed. If you are really stuck for space, and you can't make the heat room double as a washroom because of the difficulty of adding necessary plumbing, you can always do your after-sauna showering in your conventional bathroom. To illustrate how space for a sauna can be found if one is sufficiently motivated, consider the case of the unhappy Finn who had to give

Proper ventilation in a sauna is essential. The easy way to provide it is to place an air vent 3 to 4 inches in diameter under the heater so that air circulates up and around the room and escapes near floor level. One way to provide an escape opening is to make the door an inch or two short at the bottom. The adjacent room should have an outside vent.

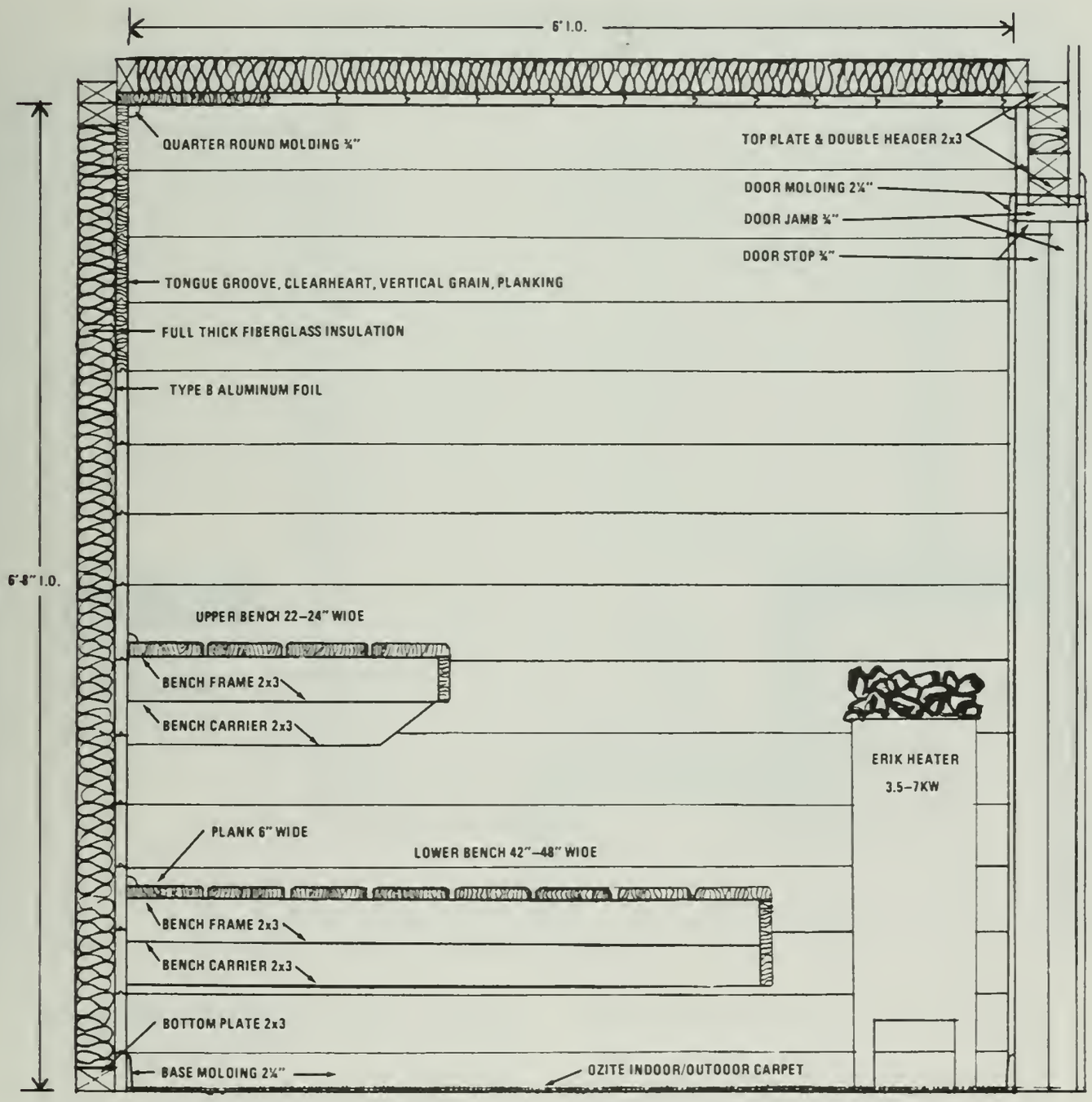




Sauna benches may be as simple or elaborate as space permits, but you should have them at two levels, 18 and 36 inches off the floor so that bathers can choose the high heat of the top bench or the milder temperature of the lower one.

up his backyard sauna when he moved to a more congested suburban community. No chance to put it in the back yard, and there was not enough available space inside the house. The solution: a sauna room was excavated underneath a small porch just off the kitchen, and a connecting door to the sauna was cut through the basement wall. A curtained-off corner of the basement was used as a dressing room.

CUSTOM SAUNA TYPE A BENCH ELEVATION & FRAMING

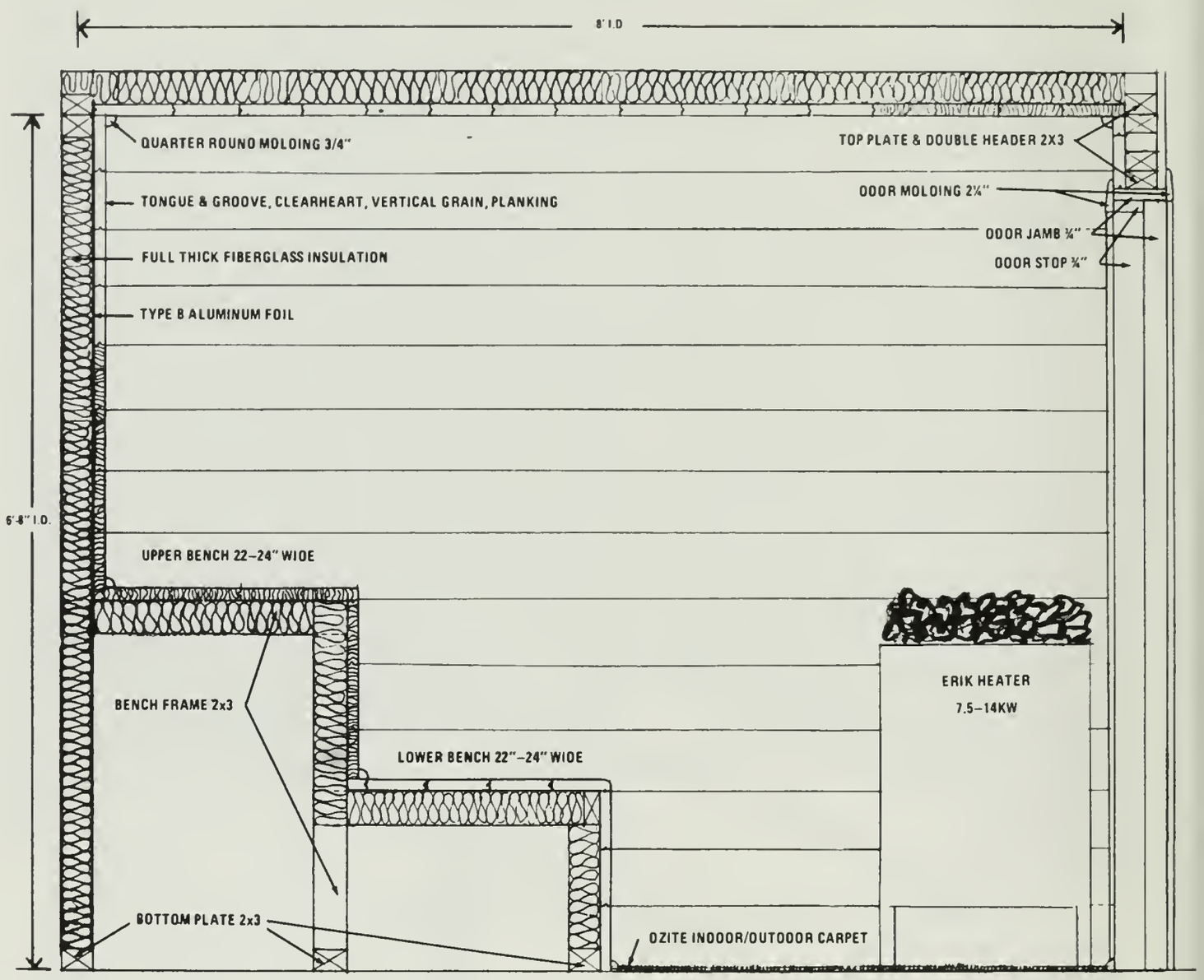


If you want good additional advice about pre-built saunas to fit your available space, you can obtain much useful information from any of several companies in the business. Pre-built saunas can be installed by company experts, or you can buy the package and do the work yourself at a saving.

The other route is to collect all the required materials and do all the planning and construction work independently. Here are some tips to get you started.

Typical sauna construction. The sauna walls can be framed in the conventional manner using 2 x 4s spaced 16 inches center to center; or you can use metal studs, or even go to concrete block walls. Check your

CUSTOM SAUNA TYPE B BENCH ELEVATION & FRAMING



local fire code to learn about any local regulations.

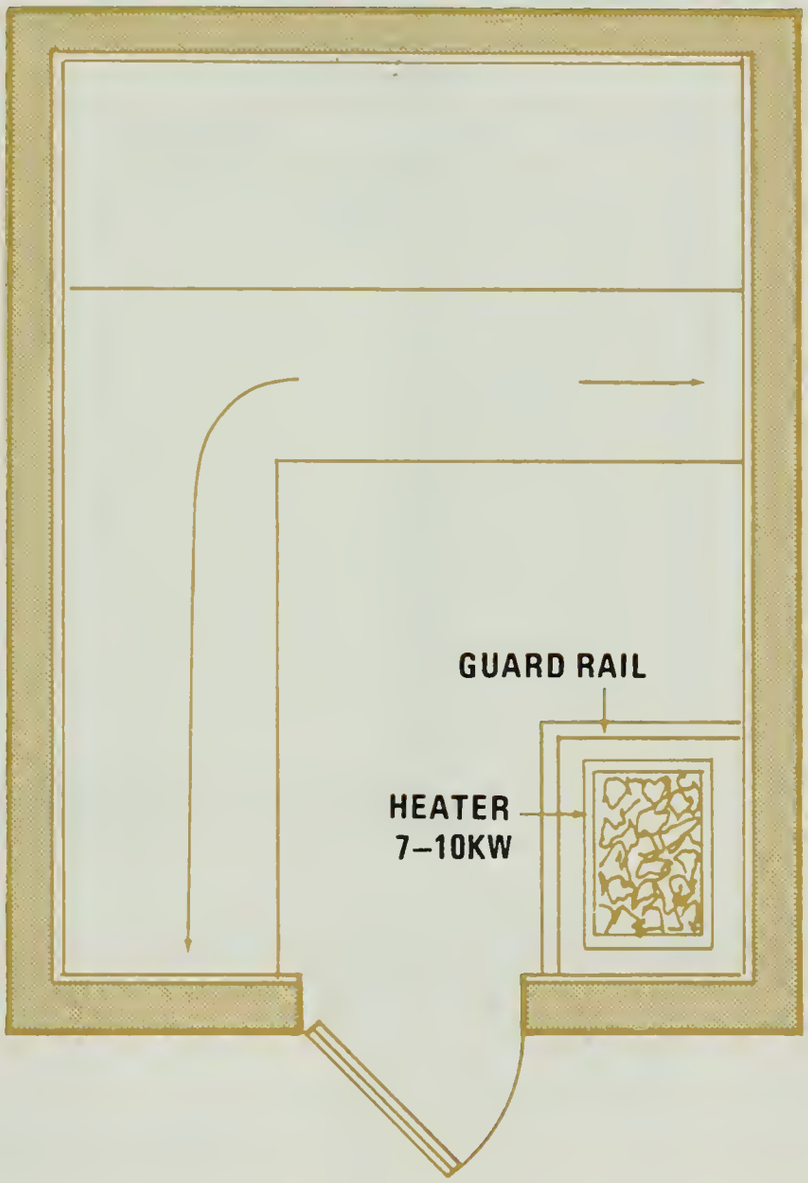
The walls and ceiling should be insulated with full thickness of foil-faced fiberglass or approved alternate insulating material. It's a good idea to add two additional layers of aluminum foil as a vapor barrier, especially if the sauna is in a place where seeping moisture could damage other parts of the home. Use kiln-dried, tongue-and-groove boarding for the interior walls. You can put the boarding vertically or horizontally to please your eye, but it seems more practical to have the grooves between the boards vertical for better drainage of condensed steam.

The ideal wood to use is either redwood or western cedar, but you could get by quite well using knot-free pine or spruce. Redwood is especially favored because it looks attractive, and it has good insulating properties and does not feel excessively hot to the touch. Redwood also is resistant to fungus growth and attack by termites, and is slow to rot.

The benches are made up of parallel

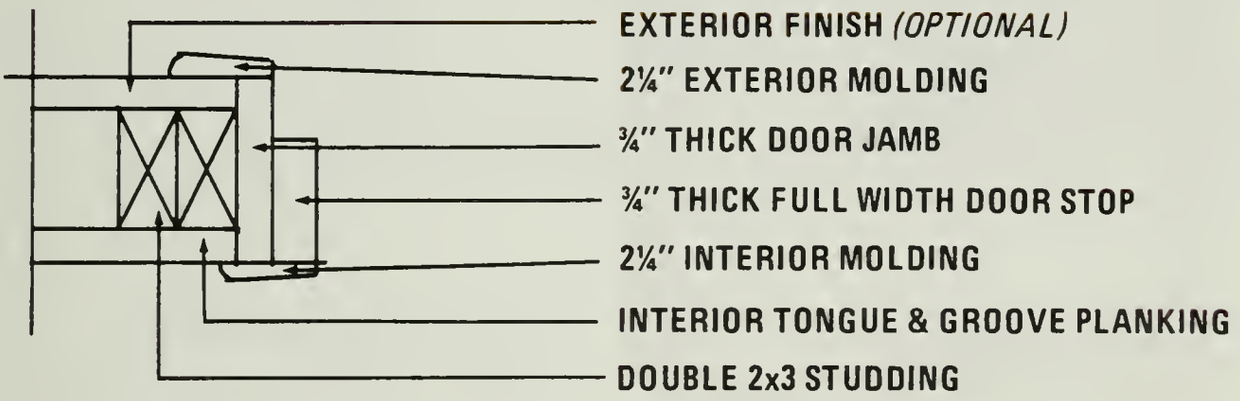
Install a Sauna Bath in Your Home 2271

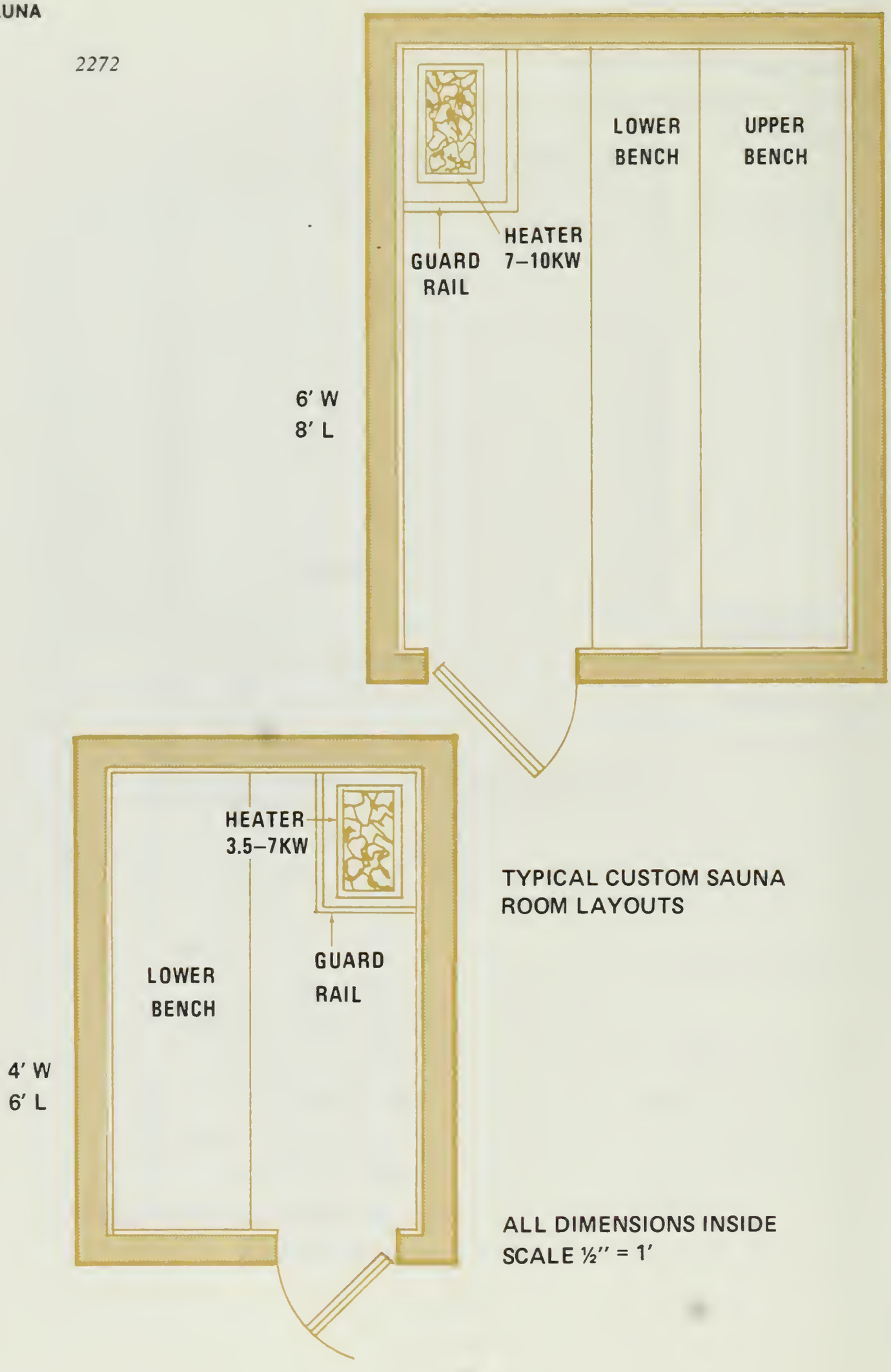
TYPICAL CUSTOM SAUNA ROOM LAYOUT



INSIDE DIMENSIONS
SCALE ½" = 1'

DOOR DETAIL



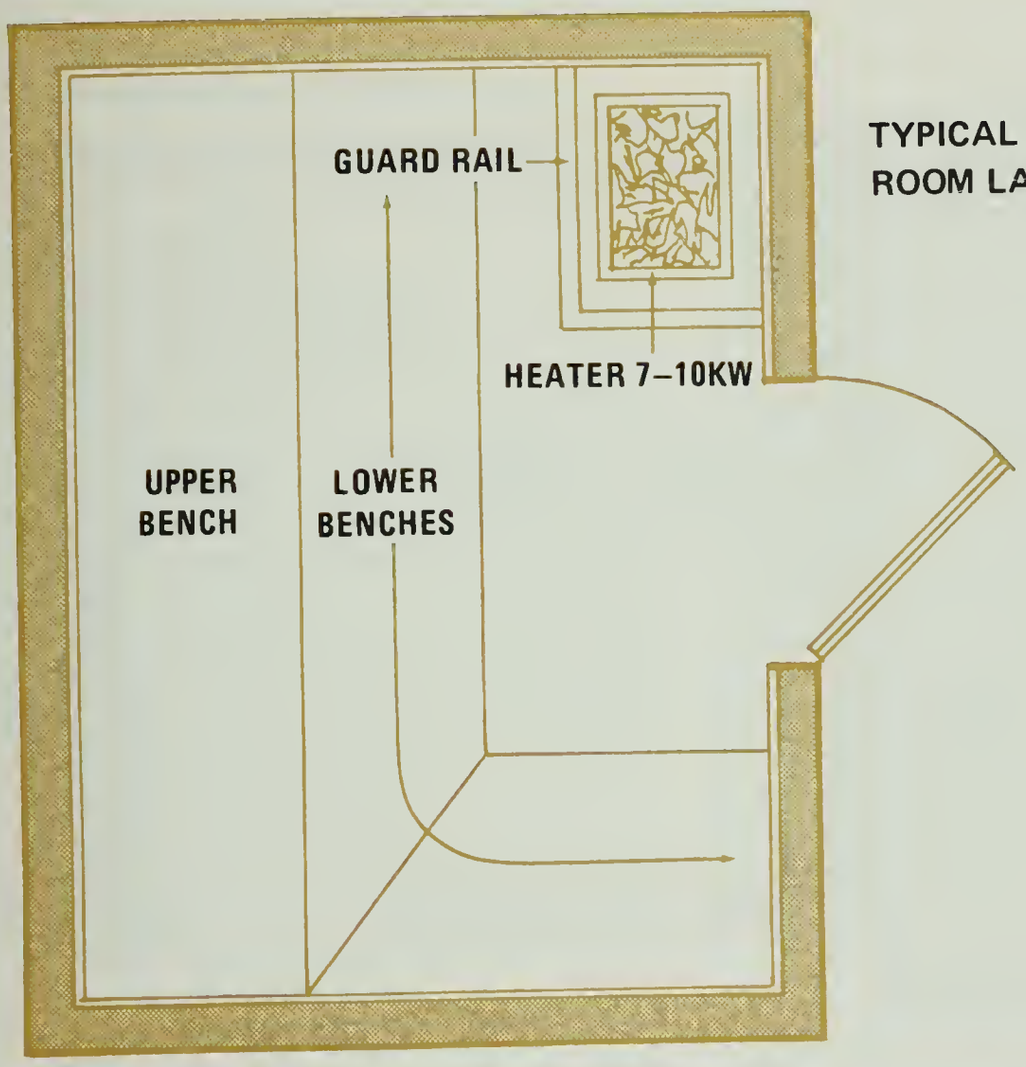


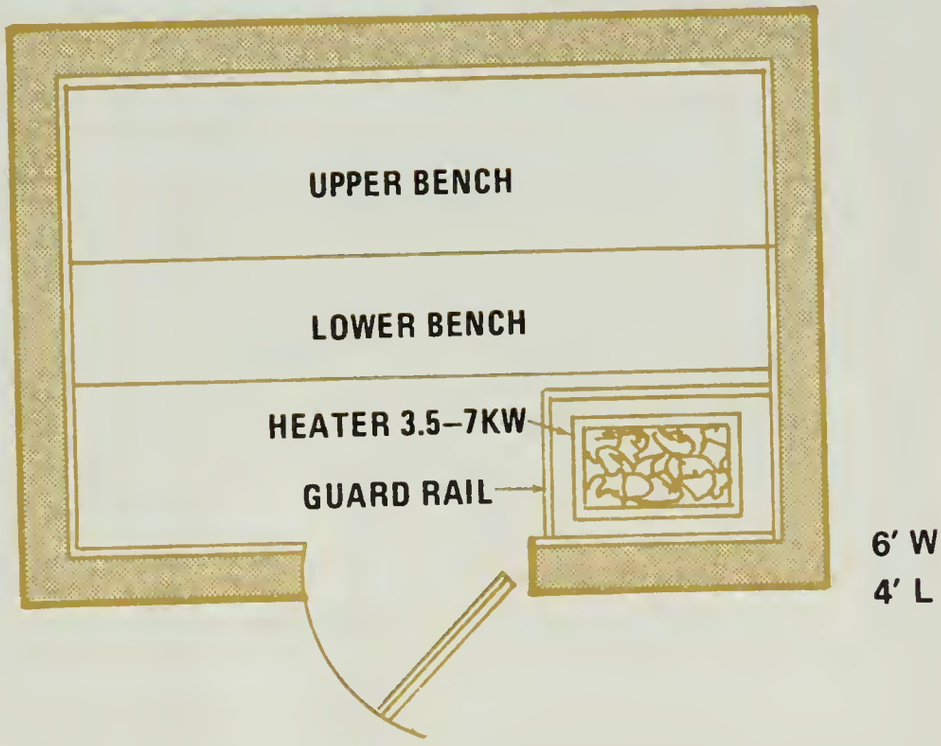
TYPICAL CUSTOM SAUNA ROOM LAYOUTS

ALL DIMENSIONS INSIDE
SCALE ½″ = 1′

2273

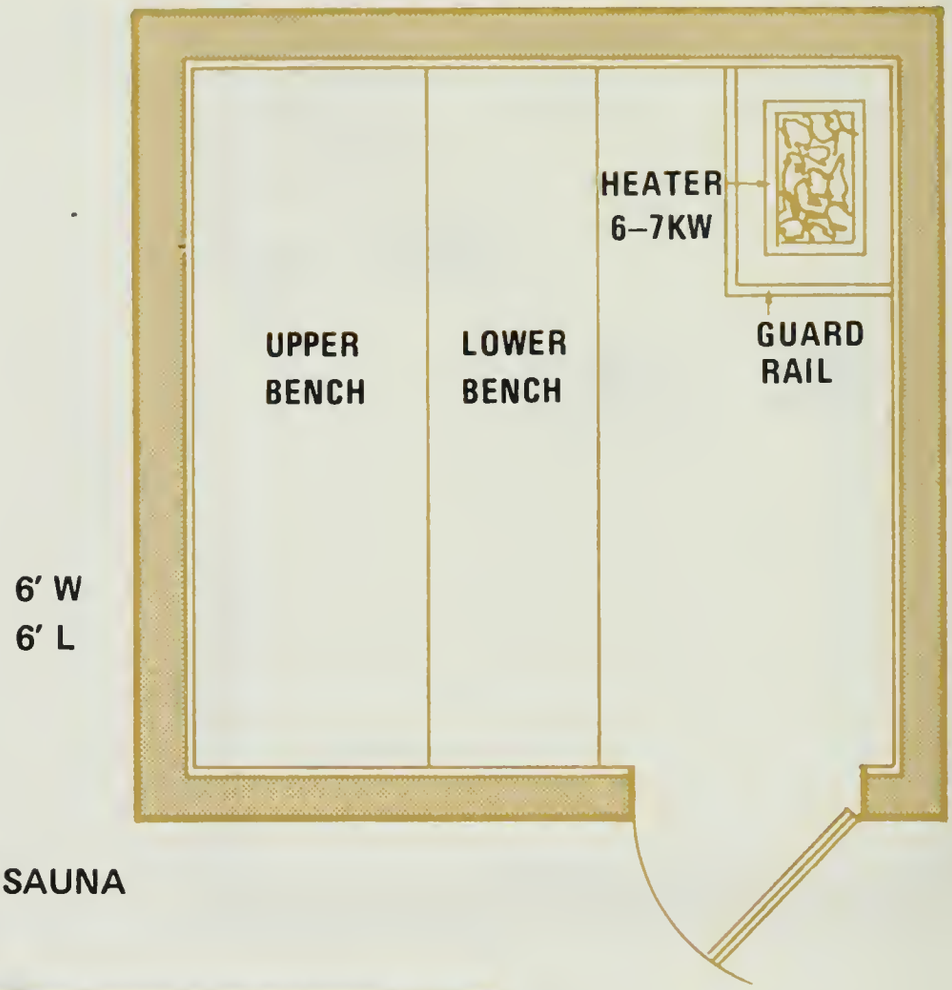
TYPICAL CUSTOM SAUNA ROOM LAYOUTS



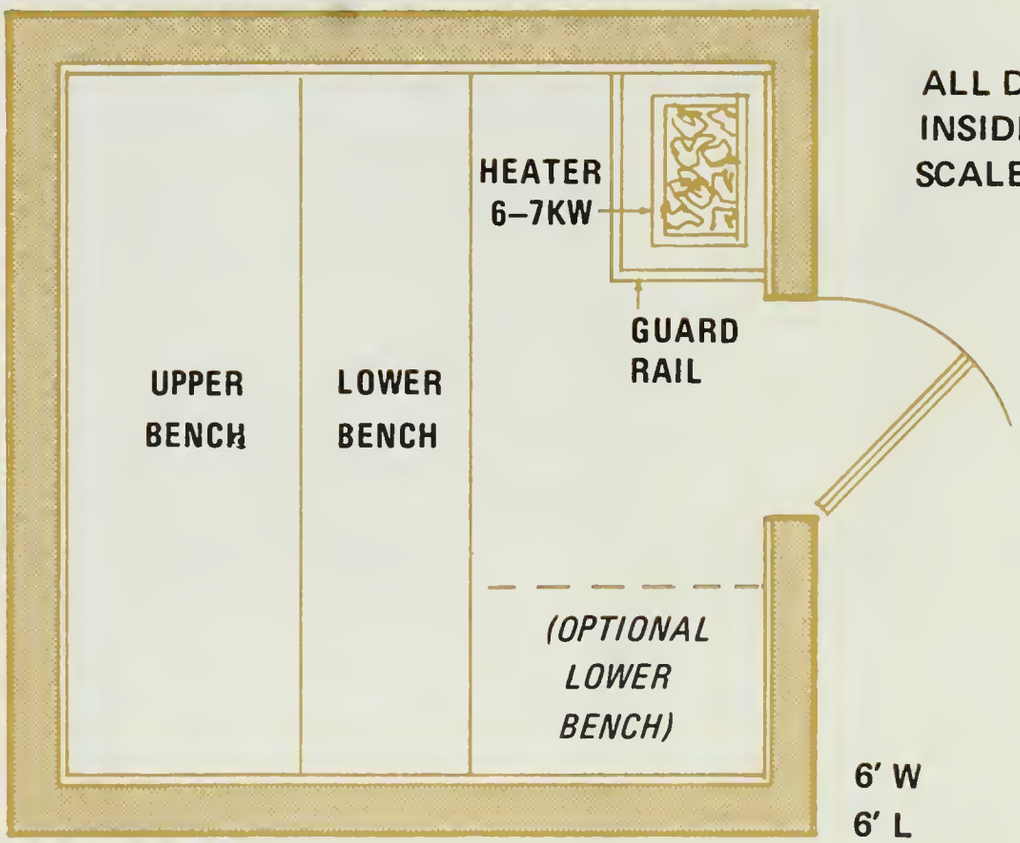


ALL DIMENSIONS INSIDE

SCALE ½″ = 1′



TYPICAL CUSTOM SAUNA ROOM LAYOUTS



ALL DIMENSIONS INSIDE
SCALE ½″ = 1′

wood slats nailed onto a supporting framework. The slats are separated about a half inch to permit water to drain off freely. Some sauna benches are made of 2 x 2-inch slats, but the more conventional styling is obtained using slats measuring about 1 x 4 inches. In a sauna where the benches stretch along a wall no longer than seven feet, you need only one set of legs in the middle to provide adequate support. The ends of the slats can be nailed to horizontal supports nailed firmly to the wall studs. Incidentally, use blind nailing wherever possible, and at the very least set nail heads to prevent skin contact. Those nails can get hot! Use aluminum, stainless steel or hot dip galvanized nails of best quality. Avoid iron and copper nails.

If the sauna room is to be used solely as a heat room, you can install shrink-resistant sisal or other indoor-outdoor type carpeting over a plywood subfloor. This feels nice on the feet, and looks good.

On the other hand, if you intend to use the same room as a washroom, you need a concrete floor with water drain. Add a duckboard made of wood slats to cover the walking area (no need to put duckboards under the benches). Keep the duckboards free so that they may be lifted vertically for draining and drying after use; this helps keep the room cleaner. Install a shower head in one corner, well away from the sauna heater.

The top bench, against the sauna wall, should be about three feet off the floor; the second bench in front of it should be at half-height. The benches should be at least 20 inches wide, preferably 24 inches, so that an adult can comfortably lie on them without fear of toppling off. If you have a really large sauna room, you can make the benches turn a corner and run along an adjacent wall as well. Thus you can provide room for more bathers. Sauna bathing is a delightful group activity since conversation flows easily in this pleasant atmosphere.

Choice of heater. Electrically operated sauna heaters come in many different sizes and designs. Some are wall-hung, others stand on the floor. Some sauna heaters operate off regular 120-volt AC power lines, while others require higher 208- to 240-volt inputs.

The relationship of heater power (in terms of kilowatts of electric consumption) to room size is to some degree a subjective evaluation, so all equipment suppliers do not come up with precisely the same figures. If the heater you choose can heat your sauna to 175°F. within half an hour, it's doing well. All modern sauna heaters made by reputable manufacturers probably work well if used according to the manufacturers' recommendations. Those units having the higher kilowatt ratings in terms of sauna volume will presumably prepare the sauna for use a little faster.

Electric heaters used by one manufacturer of pre-built saunas are made in Sweden. These units have exteriors of polished nickel steel, and they are dimensionally very compact (the smallest measures 14 x 13 x 24 inches; the largest measures 23 x 13 x 24 inches). Most of their heaters operate at 208 or 240 volts, but there is one compact model that operates off a conventional 120-volt line. The 4-, 6-, 8-, 10- and 12-kilowatt units are said to heat rooms up to 175, 350, 525, 700 and 875 cubic feet, respectively. These heaters utilize a "virtually noiseless jet air stream" to circulate the air.

Sauna heaters made in Finland are also very popular. They are used in custom saunas made by another manufacturer. One Finnish company has been making the heaters since 1919, and some 90,000 units are said to be in use today. These heaters carry over 50 pounds of "authentic black Kono rocks" which are claimed to accumulate heat faster, without cracking, than do common rocks. (Old-time Finnish saunas utilized fist-size granite glacial rocks—the

rounded glacier worn rocks of the kind you can pick up anywhere in New England farm country.) The largest heaters carry over 120 pounds of rocks. These heaters have no fans or other moving parts to get out of order. An accompanying chart shows the recommended heater power in kilowatts for saunas of various sizes.

Why the rocks? First, they serve as heat reservoirs to keep the sauna hot long after the electric heater has been shut down. Secondly, you get those delightful blasts of "Löyly" by throwing hot water on the rocks. Caution: you can get quite a heat blast from just a teacupful of water!

Ventilation. Since the typical sauna is a relatively small, wholly enclosed room, proper ventilation is important. This can be accomplished without blowers or other mechanical equipment just by locating a metal intake duct (about 3- to 4-inches in diameter) in the wall just below the heater. The outlet can be nothing more than a crack about 1 to 2 inches wide at the bottom of the door (just make the door that much shorter). You can work out other systems, even putting in a small blower if you think it's necessary, provided you bear these two things in mind: feed cool fresh air into the room at a point close to the floor, near the heater; vent the air to the outside or to an adjacent room at another point also close to the floor (so that you don't waste usable hot air which a vent near the ceiling would do).

The final touch. As already mentioned, the heater rocks are used to generate those blasts of steam. The rocks have another use—to soften the massage whisks used by the Finns. The whisk—called sauna "vasta"—is a bundle or "bouquet" of birch tree branches tied with string to form a handle at the thick end. The vasta is about 18 inches long, and the birch leaves are left on the branches. You can use the vasta when freshly made, or you can make a number of them and dry them for use throughout the winter because the leaves do not drop off very easily.

To use the vasta, prepare it by dipping in hot water and laying it on the hot heater stones for a few seconds so that the generated steam can make the thin branches and leaves supple and pliable. You then slap your body all over with the wet and steaming whisk. If this sounds a mite masochistic, perish the thought. It is a most pleasant sensation—a massage unlike any other you have ever experienced! And there's a bonus; the fragrant aromatic oils distilled from the birch leaves fills the sauna with an unforgettable scent. J.H.

See also: CHAISE.

RECOMMENDED HEATERS FOR SAUNAS OF VARIOUS SIZES

The manufacturer of HELO sauna heaters suggests the following sizes of electric heaters for saunas with room volumes as indicated:

Heater Capacity in Kilowatts	Volume of Sauna in Cubic Feet	
	Minimum	Maximum
2.4	80	120
3.6	100	200
4.8	130	180
6.0	175	350
7.2	230	410
8.0	280	460
9.0	210	540
10.0	425	600
12.0	600	775
15.0	775	1050
16.0	800	1120

WHERE TO FIND IT

For more detailed specifications and prices of heaters, write to the manufacturers of pre-built saunas. You can obtain much useful information about pre-built saunas to fit your available space from such companies as Baths International, 101 Park Avenue, New York, N. Y. 10017 (maker of Erik Sauna) and Viking Sauna Company, 909 Park Avenue, San Jose, Cal. 95126.

Handsaws and How to Use Them

The handsaw can do most household carpentry jobs just as well as a power saw, but it has one big advantage. It's handy. You can just pick it up and start sawing. You don't have to take it out of a case, or plug it in, or set it up

HANDSAWS ARE PERFECTLY adequate for most of the small carpentry chores that are done in the average home, and they offer the advantage of safety. Cutting plywood for a spice shelf, a new seat for a patio bench, a couple of fence pickets, or some tomato stakes requires very little muscle.

The most commonly sold crosscut and ripsaws have 26-inch blades of flexible steel. The crosscut, which has either 8 or 10½ teeth per inch, is used for sawing at right angles to the grain in a board. The ripsaw is generally available only with somewhat larger teeth of 5½ to the inch, and is intended for cutting with the grain. With both types, the teeth are bent over alternately from the edge, so that the channel they cut through the wood, called the "kerf," is wider than the thickness of the blade itself. This minimizes binding, especially in long cuts with the grain.

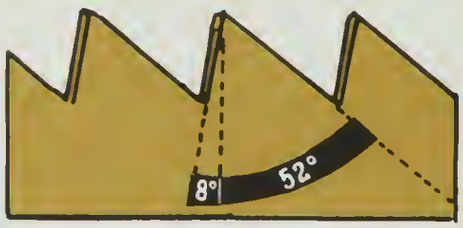
It is best not to use one saw for all cutting jobs. Many people do get along with a crosscut alone; this rather than a rip because lumber can be bought in a great variety of widths and has only to be cut to length for specific purposes. If you use a crosscut for ripping you'll find that the relatively fine teeth leave a rather tight kerf, which promotes binding. A little soap on the blade and a small wedge in the kerf help to ease the job. If you use a rip for crosscutting, you'll find that the coarse teeth leave a ragged edge on the wood. Handsaws are so inexpensive that it doesn't pay to compromise on only one.

When a board must be cut at an angle instead of directly against or with the grain, it is advisable to make a few experimental cuts in scrap pieces with a saw of each type to determine which one is suited for the particular wood. Generally, it's easier to start and control angle cuts with a crosscut than with a rip.

The backsaw is essentially a short crosscut whose blade is stiffened by a thick,

saw blades: see tool techniques
saw, chain: see maintenance, chain saw
saw, hole: see drill press
sawhorse mini-workshop: see tool caddies
schlieren bench: see science projects

CROSSCUT TEETH



RIP TEETH

U-shaped strip of iron welded to its top edge. It has fine teeth, usually 11 or 13 to the inch, and is designed for making accurate cuts, mostly in small pieces of wood. For home shop use, a blade length of 10 or 12 inches is recommended.

The trick in sawing wood is to support it firmly. A long board that is to be cut to length can be rested on a couple of boxes or chairs. To keep it from walking as you pump the saw up and down, simply press down on it with the knee or the free hand. Clamping is helpful but rarely is necessary because most crosscuts are short: about 3½ inches for a 2 x 4, 7½ inches for 1 x 8 shelving, 9½ inches for 1 x 10 shelving.

Ripping, however, is another matter. If, for example, you want to reduce the full length of a 7-foot piece of 1 x 8 to a width of 6 inches, you'll find it necessary to clamp it down on two stout chairs or boxes, with about 2 or 2½ inches overhanging in the clear to allow free passage of the saw blade. Again, press down with a knee to keep the assembly steady. Chairs make excellent sawhorses because they are of just the right height for comfortable sawing by an adult.

R.H.

See also: HAND TOOLS; SHARPENING; TOOL TECHNIQUES; TOOLS; WOODWORKING.

▲ *Clamp long board that's to be ripped to chairs or boxes. Protect the surface beneath clamp with piece of hardboard or cardboard.*

▼ *Sap from partially-cured lumber can literally gum up a saw blade. Fortunately, sap can be removed readily with alcohol.*

▲ *Periodic touch-up of teeth with file keeps saw in shape. Hold saw in special saw-vise that clamps to edge of work table.*

▼ *Gun-like tool sets saw teeth properly. Its jaws and angle are adjustable.*

▲ *Backsaw is especially good for accurate, shallow cuts. Fine teeth leave smooth finish. Scraps protect surface in machinist's vise.*

◀ *Handsaw beats power saw for cutting plywood panel down middle, as no guide is needed. Note screwdriver keeps kerf open.*

Electronic flash captures a speeding smoke ring from the air cannon in mid-flight. Largest muzzle aperture produces perfect rings that are approximately 5 inches in diameter.

All about Air Cannons

You can build a large one of these devices out of a nail keg that will extinguish a candle at 15 feet, or fire a swirling smoke ring as far as 30 feet

THIS BIG AIR CANNON will shoot perfect 5-inch smoke rings to distances of 30 feet and extinguish a candle flame at 15 feet. More than a show-stopping science stunt, this easily-built cannon will teach you much about fluid friction, fluid flow and pressure waves.

Actually we will construct three different cannons: Big Bertha; a Coffee-can Carronade; and a Pressure-wave Torpedo.

Coffee-can Carronade. You can make this little air cannon in a few minutes from a one pound size, 4-inch diameter coffee can and two plastic lids that come with these cans. Just cut the metal bottom out of the can so that it is open at both ends and snap a plastic lid on one end. Close the other end with a similar plastic lid into the center of which you have cut a ½-inch diameter hole. The cannon is finished!

If a pipe or cigarette smoker is around, have him blow a few puffs of smoke into the cannon. Otherwise generate smoke by burning a pellet of incense, a smoldering piece of paper, or some "touchpaper," which will be described later.

Hold the cannon horizontally and gently tap the center of the un-perforated plastic lid. Perfect smoke rings will shoot out of the hole in the other end.

If the smoke in the cannon isn't very dense, you may have trouble seeing the rings clearly in a brightly lighted room. But they will be very easy to see if you view them against a black background, and especially if you shoot them along a beam of light—as from a slide projector—in a half-darkened room.

Experiment with holes of different sizes cut into other plastic lids. By cutting several small holes into one lid, a single tap will produce more than one ring at a time. Try square, rectangular and triangular holes as well as round ones. Or cut a ⅛ x 1-inch slit into a cover. In what shape will the smoke be? Try it. You may be surprised at the results. If you can't get enough plastic

scion: see grafting
scrambler: see telephone
scraper: see hand tools
scrap lumber: see lumber
screen, patio: see patio

lids for your purposes, cut holes in cardboard discs and tape them to the can. They work just as well, but the plastic lids can be interchanged more conveniently.

Big Bertha. This air cannon is made from a discarded wood or fiber nail keg about 18 inches long and 11 inches in diameter. A local building contractor, hardware or lumber supplier should be able to provide a similar barrel. If you can't locate one, make a similar tube from heavy cardboard or sheet metal.

If the bottom of the keg is in good condition, cut a 5-inch diameter hole in its center. Remove the bottom from a 4-inch diameter coffee can and cut it down into a 2-inch long tube with tin shears. Push the cut end into the hole in the keg bottom and tack the can into place to form the cannon's muzzle.

If the bottom of the keg is in poor condition, replace it with a new one cut from ½-inch plywood.

You need a flexible diaphragm on the other end of the keg. The best material to use is sheet rubber which you can buy at an infants' supply store. It is sold as protective water-proof sheeting for use in baby cribs. Get the pure rubber kind, not the type with a felted nap on one side.

The nail keg probably has a wooden retaining ring on the inside, about an inch from the rim of the keg. This originally kept the lid from falling into the keg. If the ring is missing or damaged, make a new one by carefully bending a 1-inch wide strip of Masonite into a ring of the proper size.

Make a second retainer ring of the same size. Lay a sheet or rubber over the open end of the keg and force the second ring down on it until the rubber is pushed against the inner retaining ring. Use large spring paper clips or C-clamps to hold the outer ring in place as you gradually pull the rubber diaphragm even and taut to form a tight drumhead. Keep the clamps in place until you have secured the outer retainer ring. Ordinary small electrical staples used to tack lamp cord to walls hold very well. Trim off all excess rubber to make a neat job. An exploded view of the entire assembly is illustrated.

Gun carriage. The gun carriage is con-

▲ *Small cannon materials. Can has both ends off. Note various holes in the plastic.*

▼ *Rubber diaphragm is held taut in rear of barrel by a stapled Masonite ring.*

structed from plywood. The cannon will, of course, operate without this carriage, but it makes it look more like the real thing. The carriage also makes it easier to tilt and aim the cannon. The bottom and all sides are made from ½-inch plywood.

A 13¾-inch length of ⅜-inch thick threaded rod (hardware store) runs all the way through the carriage and barrel to support the barrel. Use large washers on both sides, between the barrel and the carriage, and also on the outsides of the carriage to keep the nuts from digging into the wood. Paint the cannon and carriage red, with black trim, or any colors you choose.

Touch-hole generator. You can charge the cannon with smoke by way of the muzzle, but if you have come this far you should dress up the cannon with a "touch-hole" that also serves as an efficient smoke generator.

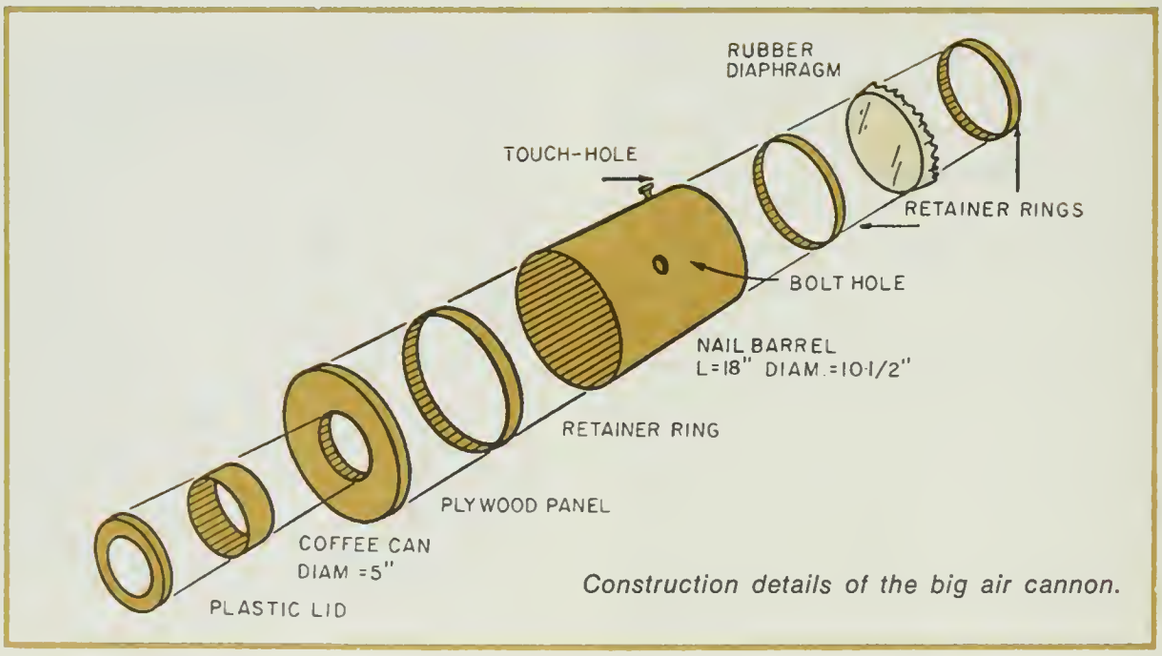
The touch-hole is nothing more than a 2-inch length of ½-inch diameter metal tubing thrust part way through a hole drilled near the rear of the cannon. The smoke generator is made from a 5½-inch length of tubing of slightly smaller diameter so that it can slide into the touch-hole.

Solder a small metal cap on one end of the tube, and a larger one on the other end to keep the tube from dropping into the keg. Cut out a section of tube as shown in the illustrations, leaving a shallow cup, about ⅛-inch deep, at the bottom end. It is important that you do not make this cup too deep.

Muzzle caps. The cannon will not blow smoke rings properly unless you fit the muzzle with a cap with a hole in the center as shown in the illustration. Five-inch diameter plastic coffee can lids are handiest to use because they can be interchanged quickly to vary the sizes of the apertures. You can cut apertures ranging in size from ¾-inch to 4⅜-inch in diameter to blow various sizes of smoke rings. The aperture shown is 2⅝-inch in diameter.

Take particular note of the very large aperture shown. There is only about ¼-inch of plastic around the hole, but enough to make the cannon work efficiently. Eliminate this ¼-inch entirely, and the rings won't form.

Smoke generation. Pipe and cigarette smoke work well, but don't take up smoking to operate your cannon. There are more convenient ways to generate smoke.



Construction details of the big air cannon.

The best way is to charge the touch-hole generator by placing a pellet of incense in the cup and lighting it. In a minute or two, the cannon will contain enough smoke to blow dozens of rings. A particular advantage of incense is that it has a pleasant odor, rather than the acrid smell you would get from, say, smoldering paper.

You can make so-called "touch-paper" by soaking mimeograph paper in a 5% to 10% solution of sodium or potassium nitrate. After the paper is dry, roll 3-inch square pieces into the shape of thin tubes. When lighted, this paper will not burn with a flame, but will smolder in much the same way as "punk" used to light fireworks. The only drawback to touch-paper is that it produces a rather annoying odor. If you must use it, provide good ventilation in the room.

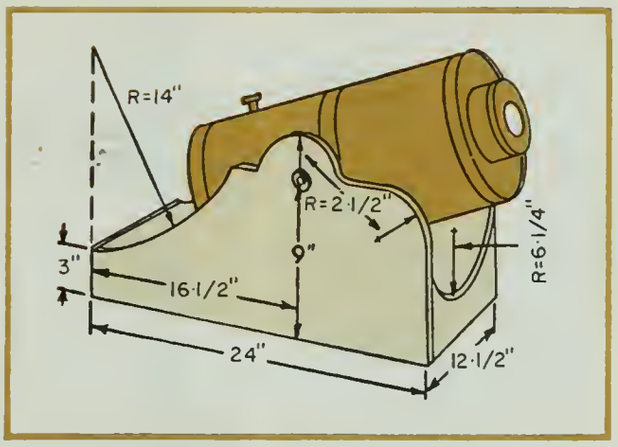
Lighting conditions. The smoke rings are seen to best effect in a darkened room as they travel along the length of a bright beam of light. If you have a slide projector, set it up as shown in the illustration. Otherwise you can improvise a crude spotlight by fitting a light bulb in one end of a long sheet-metal tube.

Experiments with Big Bertha. Holding your fingers straight and side by side, smartly rap the center of the rubber diaphragm. A perfectly-formed, swirling smoke ring will speed across the room. One ring after another can be generated about as fast as you can tap the diaphragm.

Place a lighted candle about 10 feet away, aim the cannon at it, and fire. If your aim is good, the smoke ring will extinguish the candle with an audible snap. With practice, and providing the air in the room is still, you can blow the candle out from distances of 15 feet or more. Spectators are invariably surprised because the average person can blow a candle out from a distance of no more than 4 feet.

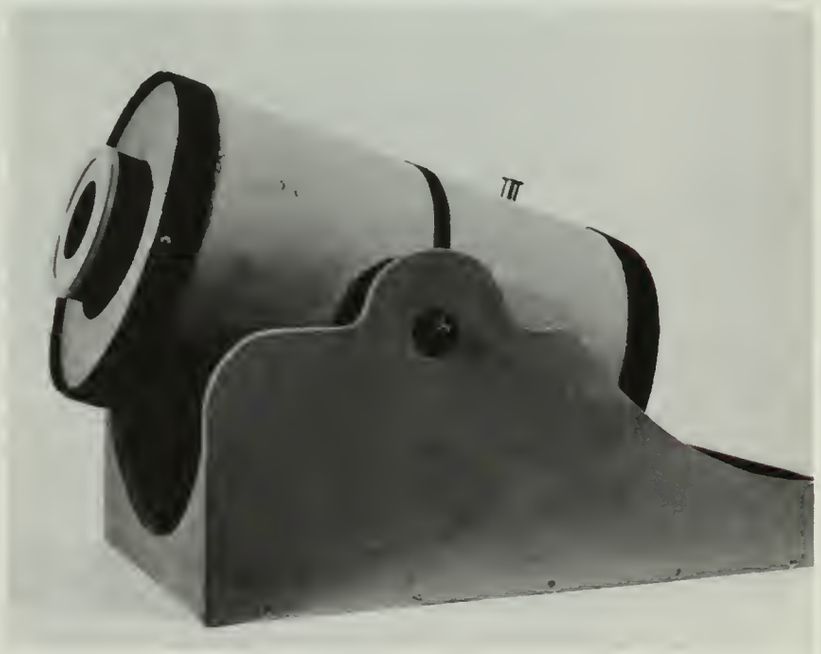
The smoke, of course, has nothing to do with extinguishing the candle; it's the pressure wave that does it, as you can prove by repeating the test without smoke in the cannon. The smoke makes aiming the cannon easier and makes the demonstration showier.

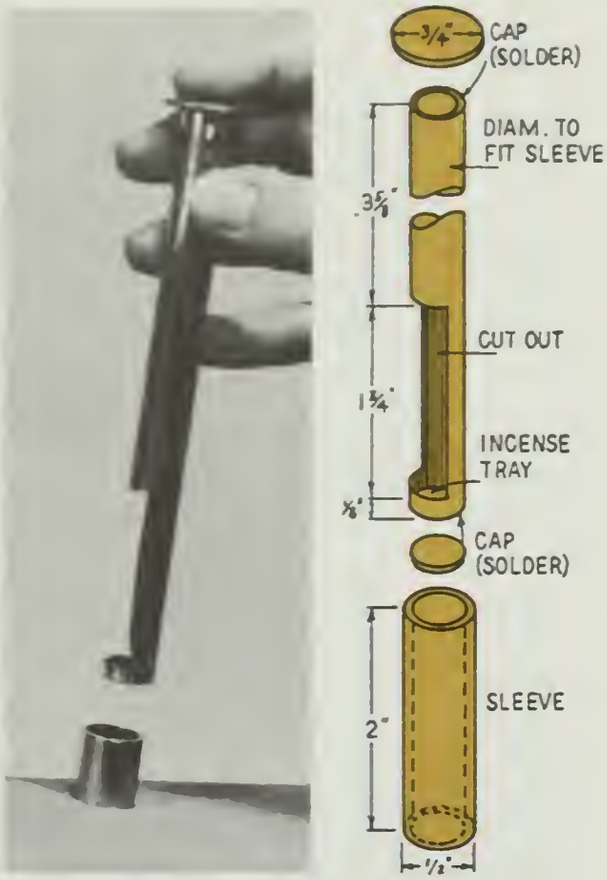
The smoke also reveals some interesting things about the nature of the otherwise invisible pressure wave. The pressure ring is formed by streamlines generated at the muzzle aperture by fluid friction forces. This imparts an internal swirling action to



▲ *Dimensions of the big air cannon.*

▼ *Cannon is pivoted on plywood carriage to facilitate aiming at targets. Note coffee can muzzle and touch-hole smoke generator at top.*





Metal tube with both ends closed and a slot cut in the lower end is a simple but effective smoke generator. Incense pellets are burned in bottom cup. Tube slides in through touch-hole metal sleeve.

the pressure wave. The smoke makes these swirlings clearly visible.

This smoke ring is a good example of a so-called vortex ring, an important phenomenon in the field of fluid dynamics. A complete mathematical description of the phenomenon would require the use of elliptic functions. A detailed analysis and description of the mechanism of vortex smoke ring formation would provide a challenging research project for those who are mathematically inclined.

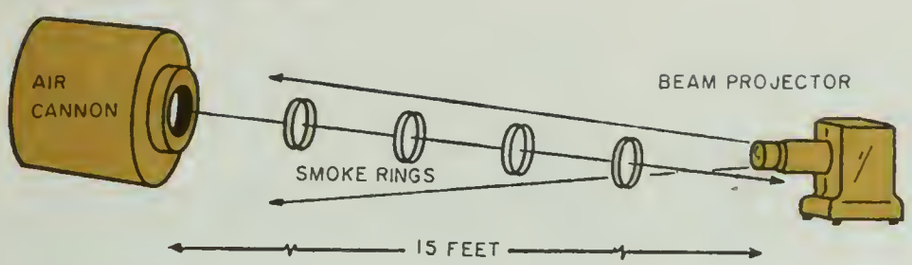
A more sophisticated experimental study of vortex ring formation might involve such technical problems as (1) controlled impact against the rubber diaphragm, (2) accurate measurement of the pressure build-up inside the cannon, (3) measurement of the speed of the emerging pressure wave and other factors.

Motion pictures made of the emerging smoke ring might be quite revealing. They might provide a means of measuring the ring's travel speed and, if studied in slow motion or as still frames, might provide clues about the way in which the pressure waves are actually generated at the muzzle aperture.

Strato-cannon. It is reported that some scientific experts have seriously considered the possibility of using super air cannons to shoot industrial waste gases and other air-polluting materials into the stratosphere! This theoretical application of the air cannon might make an excellent subject for a science fair demonstration.

The exhibit might include a model industrial plant, with a working strato-cannon blowing smoke rings into the "stratosphere." Your own scientific research on the problem might lead to theoretical conclusions about the type and power of equip-

Muzzle is made from cutdown coffee can with ends removed. Lids with holes of various sizes spell easy change of muzzle aperture.



Recommended position of slide projector for best viewing of smoke rings. See text for alternate lighting.

The pressure ring is formed by streamlines generated at aperture by fluid friction forces.

ment that would be needed to send the pressure waves so high. And, of course, you should ponder the probable consequences of loading the stratosphere with polluting materials. For example, what adverse effects might they have on aviation, astronomy, or even earthbound activities which depend on sunlight? Another interesting point: Would the pollutants stay in the stratosphere permanently?

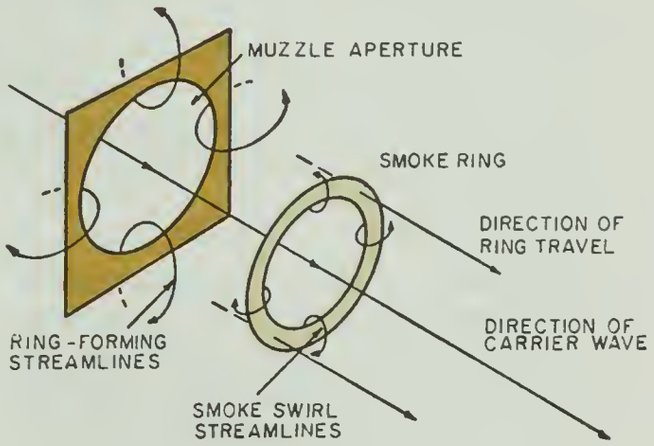
Pressure-wave Torpedo. The air cannon clearly demonstrates that fluid friction forces can produce powerful pressure waves. In fact, it is reported that cannons capable of knocking a man off his feet at a distance of 20 feet have been constructed!

But so far we have considered only the problem of ring formation in a gaseous medium—air. Would similar forces apply in more dense fluids such as water?

You can very easily demonstrate that they do, by making a small under-water cannon—a pressure-wave torpedo—if you like.

Make the cannon from a 3-inch length of plastic, metal or glass tubing about 1-inch in diameter. Make a diaphragm on one end from a rubber balloon, holding it in place with rubber bands. Close the other end with some sort of waterproof disc with a ¼-inch hole in it. This can be of metal, and soldered on, if you use an iron, copper or brass tube for the body of the cannon.

Now completely fill the cannon with water, colored with ink, food-coloring dyes or watercolors. Immerse the cannon in clear water in a basin or bathtub and tap the diaphragm. Colored rings, very similar to smoke rings, will shoot through the water.



The rings are, of course, formed even if you use clear water in the cannon; the dye simply makes them clearly visible. This simple experiment, too, might suggest some interesting research projects. For example, could you construct a somewhat larger underwater cannon and test it in a swimming pool or pond? Perhaps you could use it to send invisible and inaudible signals through the water. How might you build a target that would convert the impact of each pressure wave into a visual or audible signal?

Here's another thought: Would it be possible, at least in theory, to build a powerful underwater cannon that could blow away loose sediments in the bottoms of lakes or the ocean for sub-surface exploration?

These air and water cannons are well worth building even if you do nothing more than use them for demonstration purposes, or as fascinating party games—such as blowing out candles in the least number of shots. But they can also be used as more serious scientific tools. J.H.

See also: COMMUNICATIONS; LASER; MICROPHONES.

Experimenting with Loudspeakers

Make a musical card table, an under-pillow speaker or simple dynamic earphones in this series of inexpensive experiments

YOU CAN GET A GOOD workout reading about the theory of dynamic loudspeakers in textbooks. But it is far more fun to actually perform some experiments that show you how they work. Musical card tables, dynamic earphones and under-the-pillow speakers are just a few of the simple but intriguing and inexpensive projects you can make.

The construction of a typical PM (permanent-magnet) dynamic loudspeaker such as you have in your radio, is shown in the drawing. This drawing shows an Alnico slug used to supply the necessary magnetic field. Some dynamic speakers, however, use a field-coil consisting of many turns of small enameled copper wire surrounding an iron core. Direct current passing through the coil creates a magnetic field within the iron core. For economy and to simplify construction problems, such a field-coil is often made to double as a choke-coil in the power supply of a radio.

The North pole of the Alnico slug forms the center pole of the magnetic field, while the South pole flux passes through both sides of the iron frame towards the North pole. Since like poles repel and unlike poles attract, a powerful magnetic field is created in the air-gap between the poles. This air-gap, purposely shown enlarged in the drawing, is actually made as small as possible in order to intensify the magnetic field.

The voice-coil, usually a number of turns of fine enameled copper wire around a thin paper collar, is centered and held within the magnetic field air-gap by a flexible support called a "spider." This spider is usually a corrugated disc made of material that is very flexible in the longitudinal direction, but stiff in the transverse direction.

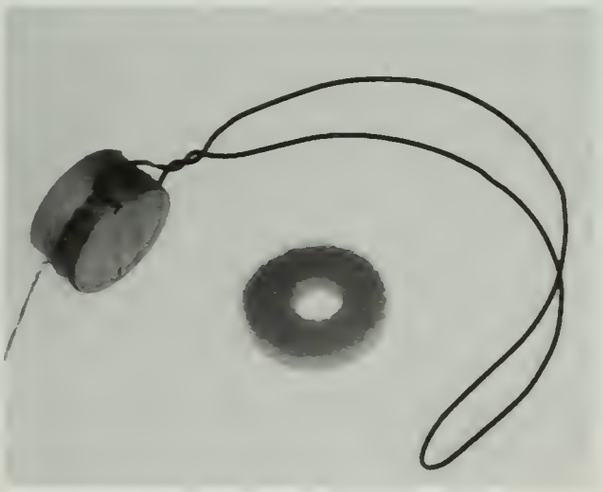
Thus the spider allows the voice-coil to move freely forward and backward, but prevents it moving from side-to-side. The cone (also called a "diaphragm" or "piston") is formed from treated paper. Its apex is cemented to the voice-coil, and its outer edge is supported in the ring of the "basket" by a flexible suspension, usually consisting of corrugations in the outer edge of the paper cone itself. As audio-frequency alternating currents flow through the radio's output transformer and through the speaker voice-coil, magnetic fields of rapidly varying polarity, strength and frequency are set up within the voice-coil. These voice-coil magnetic fields are alternately attracted or repelled by the powerful magnetic field in the air-gap, thus causing the voice-coil to vibrate forward and backward at the audio rate. And since the voice-coil carries the cone along with it, the cone sets up sound

waves which are a reasonable facsimile of the sound waves that enter the microphone at the broadcasting station.

To see how a coil with a magnetic field of changing polarity behaves when placed close to a strong magnetic field, rig up the simple device shown in the photograph. Mount an Alnico slug on top of a gum eraser and bind these parts together with cellulose tape. Wind about 40 turns of #28 insulated copper wire around a small paper or cardboard tube, or plastic top, and coat the coil with glue or with airplane model cement so it won't unwind. The coil is supported by its two leads so it stands in mid-air about ¼-inch away from the end of the magnet, using thumbtacks stuck in the wood base as shown. The photographs show what happens when a 1½-volt flashlight cell is momentarily connected to the coil. If you should connect the battery and coil to a DPDT knife-switch, the polarity of the connections from battery to coil can be reversed by throwing the switch from side to side. Thus you can make the coil move forward and backward as fast as you can operate the switch. In other words, you make the coil vibrate by alternating the current flowing through it; the same effect takes place in a loudspeaker, although the method of producing the alternating current is different. The tone generated by a speaker cone depends on the number of times the cone vibrates per second, while the tone intensity depends on how far the cone moves during the vibrations.

Thus, a loud bass tone is produced by slow but vigorous excursions of the cone, while soft treble tones are produced by very rapid but feeble excursions. Because a large cone is too heavy to vibrate efficiently at the very high frequencies, and a small cone cannot push enough air to fill a room with bass, hi-fi units often combine the two to reproduce the entire musical range. This hi-fi combination of "woofer" and "tweeter" units as they are called, is known as a coaxial speaker.

You can connect the coil to the output transformer of your radio and hear the



▲ *Dynamic earphone with headband bent from a wire clothes hanger. Plastic sponge material when cemented to box top, cushions and holds the vibrating box top slightly off the ear. Two of these phones may be connected in series to form a double headset.*

◀ *This simple 8-inch PM dynamic speaker cost pennies to make, yet its reproduction is surprisingly clear; has enough volume for a small room.*

broadcast program. But due to the poor sound radiating ability of the coil, and the poor magnetic coupling between the coil and the magnet, the sound output is so low you will have to put your ear very close to the coil in order to enjoy it..

If you have an Alnico slug, the earphone shown in the photograph should cost you nothing to make, yet you will be pleasantly surprised by its performance. While its efficiency and tone quality cannot equal that of commercial dynamic earphones, it is good enough to use for late evening listening without disturbing those who have retired. Its impedance of around 6 ohms makes it a good match for the secondary of the output transformer on your radio and the diagrams show how this connection is made after you have built the earphone.

The earphone shown here was made from a ⅞-inch diameter Alnico-V slug ¾-inch long salvaged from a junked 5-inch PM speaker. The slug was cemented to the inside center of a round 1¾ x 1-inch paper thumbtack box using model airplane cement. For the voice-coil, 40 turns of #28 *Cottenamel* copper wire were jumble-wound around a 1-inch diameter, ½-inch long paper collar. The cement applied to coil kept it from unwinding. The voice-coil and magnet were cemented to the exact center of the box lid, so that when box is closed, the coil encircles the top edge of the Alnico slug without actually touching it. If it does touch, you'll get a raspy tone. Punch wire lead holes in box as shown. The photograph shows completed earphone with a headband bent from a wire clothes hanger. Flexible rubber-covered wires soldered to voice-coil leads and secured to inside of box keep the voice-coil from being damaged by pulling on the cords. Since the voice-coil vibrates the box lid, making the lid a sound-radiating diaphragm, it's best to hold the phone off the ear slightly while listening. To do this, cut a large hole in the center of a foam-rubber powder puff. Then cement the puff onto the outer edge of the box top with rubber cement. Remember, the stronger the magnet used, the closer you get the voice-coil to the magnet without touching it, and the larger the box top diameter—the greater will be the sound output of this simple dynamic earphone.

▲ *Coil repels magnet and pulls away from it because its magnetic field polarity is the same as that of the magnet.*

➤ *With battery connections reversed (battery now upside down), coil clings to magnet because its magnetic field polarity is now opposite that of the magnet.*

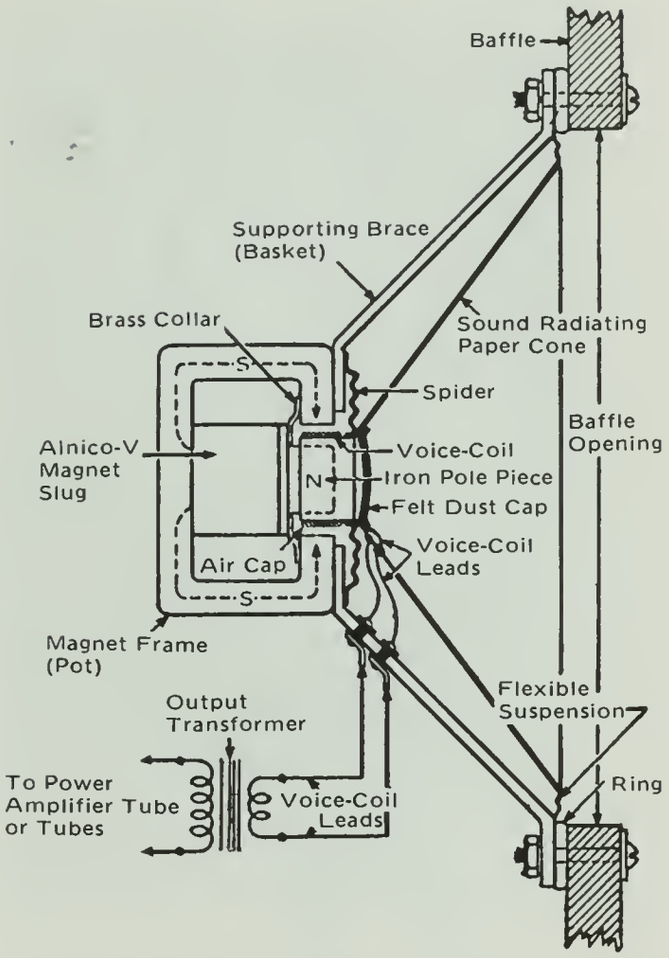
Experimenting with Loudspeakers

With a simple dynamic speaker placed underneath your pillow, and with your ear on the pillow directly over the speaker, you can listen to late programs without disturbing others. Both pillow speakers shown in the photographs are built in exactly the same way as the dynamic earphone; in fact, they are simply enlarged earphones with a larger sound-radiating surface. To extend the magnet so that it will reach into the voice-coil, cement an iron pole-piece to the slug. Use a pole-piece salvaged from an old speaker, or a slug of iron rod of the required diameter. Or make the voice-coil form long enough to allow the coil to encircle but not touch top edge of magnet.

Before cementing slug and voice-coil to plastic, clean and scrape plastic surface so cement will hold. Use light-weight plastic-covered lamp cord for this speaker. Tie a knot in the cord and cement this to the inside of the case. Solder voice-coil leads to ends of lamp cord.

In the second pillow speaker project, the voice-coil is wound on a plastic tube, and connections are made to the speaker through two phone-tip-jacks fastened through sides of the plastic compact. The soap-case speaker gives a little more volume than the plastic-compact speaker because of its thinner lid of somewhat larger surface area. But both perform surprisingly well for such simple devices.

The principle of bone-conduction hearing aids can be used as the basis of another interesting experiment. For this experiment, jumble wind about 40 turns of #28 or #30 insulated copper wire around the end of an 8-inch long piece of ½-inch wood dowel. Wind wire tightly, as close to the dowel end as possible, then coat with glue or model airplane cement to keep it from unwinding. Connect leads of coil to output transformer of your radio, hold wood dowel in your teeth as shown, and then hold an Alnico slug close to the coil. As the voice-coil vibrates at the audio rate in the magnetic field of the slug, the vibrations pass through the dowel, through your teeth and skull, and excite your auditory nerves, thus giving you the sensation of sound. If you turn up volume control, you will hear the music and understand the spoken words.



Typical PM dynamic speaker on a baffle.

Entertain your friends by having their favorite radio programs radiate right off the center of the card table top while you play cards. The drawing shows the simple setup. Secure the familiar magnet-and-coil combination to the underside center of the card table top as shown, and make the connections from the voice-coil to your radio's output transformer using a short length of POSJ lamp cord. Bring cord off the table at a corner so it won't be too much in the way. This musical card table works on exactly the same principle as the projects

Interior view of simple dynamic earphone made of a section cut from a mailing tube. This also provides driving unit for dynamic speaker.

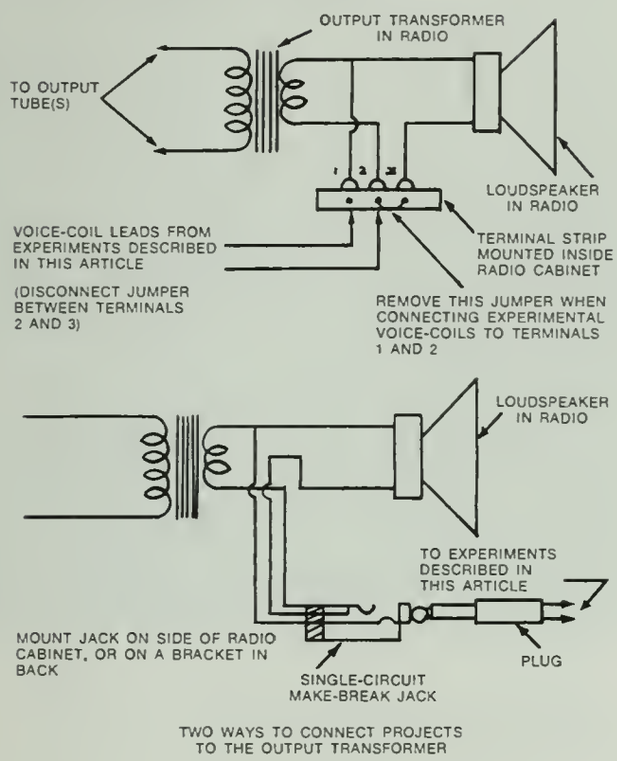
previously described, but you will hear more bass because of the larger radiating area of the table top. Use the most powerful magnet you can get, and place the coil as close as you can to the slug, without actually touching it.

It costs less than a dime to make a simple 8-inch PM dynamic speaker. Of course, its efficiency and tone quality does not equal that of a factory-made speaker, but it reproduces clearly and has enough volume for a small-size room. To build this speaker, first make an earphone unit. Then form an 8-inch diameter cone from a sheet of double-weight paper (poster or construction paper), cut the tip off the cone's apex, and then cement the cone to the center of outside of box lid as shown in the drawing.

The box lid now acts as a spider and the cone radiates sound waves by acting as a piston. To make the spider more flexible

Under-the-pillow speaker built from a plastic container originally holding electrical tape. Coil is wound on a plastic or cardboard tube. Connecting cord plugs into the phone-tip-jacks. The cover must be notched where jacks protrude from the lower half of the container.

Under-the-pillow speaker, built in a soap case, showing cord and plug attached to that unit. Magnet and coil are inside case.

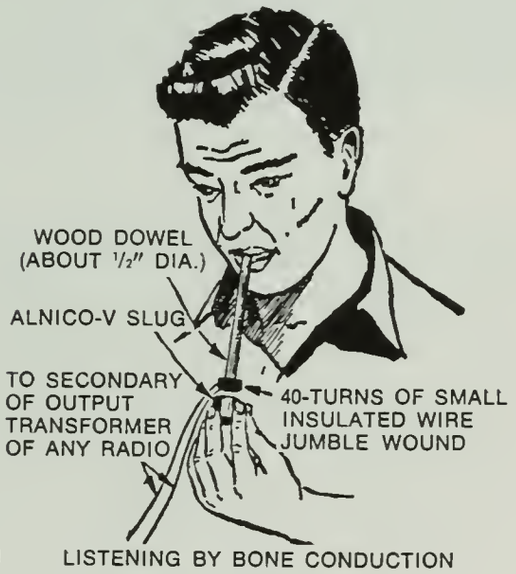

OUTPUT TRANSFORMER IN RADIO
TO OUTPUT TUBE(S)
LOUDSPEAKER IN RADIO
VOICE-COIL LEADS FROM EXPERIMENTS DESCRIBED IN THIS ARTICLE
TERMINAL STRIP MOUNTED INSIDE RADIO CABINET
(DISCONNECT JUMPER BETWEEN TERMINALS 2 AND 3)
REMOVE THIS JUMPER WHEN CONNECTING EXPERIMENTAL VOICE-COILS TO TERMINALS 1 AND 2
LOUDSPEAKER IN RADIO
TO EXPERIMENTS DESCRIBED IN THIS ARTICLE
MOUNT JACK ON SIDE OF RADIO CABINET, OR ON A BRACKET IN BACK
PLUG
SINGLE-CIRCUIT MAKE-BREAK JACK

TWO WAYS TO CONNECT PROJECTS TO THE OUTPUT TRANSFORMER

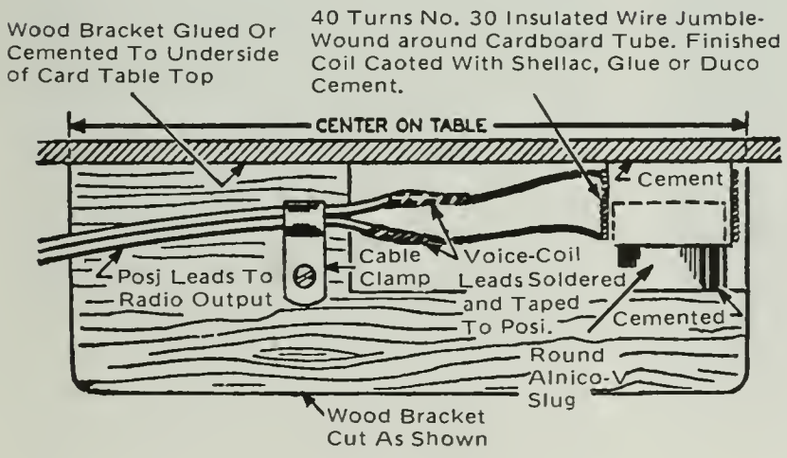
you can punch or burn small holes in a circle around the outer edge of the box top, but leave the box top stiff enough to support the cone and voice-coil so they won't tilt. Bend a stand from a wire clothes hanger as shown, or make an angle bracket from wood and glue back or paper box onto wood upright.

To use the projects described here, you must connect them to the output transformer secondary winding in your radio. The output transformer is usually mounted right on the frame of the speaker, and the two short wires from the transformer to the speaker voice-coil are the ones you want. Disconnect one of the leads, using a soldering iron if necessary. But don't disturb the long leads from the transformer to the output tube(s) plates. For temporary hook-ups, use alligator clips. For longer lasting, neater looking connections, use one of the methods in the diagrams shown. None of the dynamic units here will work with crystal sets, because the voice-coil impedances are too low, but they do match the output transformer in your receiver. Ask local radio service shops for junked PM speakers they intend to throw out. You can remove the Alnico slugs and iron pole-pieces by sawing through frames and prying frames apart to release the magnets. A.T.

See also: ELECTRONICS; MICROPHONES.


WOOD DOWEL (ABOUT 1/2" DIA.)
ALNICO-V SLUG
TO SECONDARY OF OUTPUT TRANSFORMER OF ANY RADIO
40-TURNS OF SMALL INSULATED WIRE JUMBLE WOUND

LISTENING BY BONE CONDUCTION


Wood Bracket Glued Or Cemented To Underside of Card Table Top
40 Turns No. 30 Insulated Wire Jumble-Wound around Cardboard Tube. Finished Coil Caoted With Shellac, Glue or Duco Cement.
CENTER ON TABLE
Cement
Cable Clamp
Voice-Coil Leads Soldered and Taped To Posi.
Posj Leads To Radio Output
Cemented
Round Alnico-V Slug
Wood Bracket Cut As Shown

MUSICAL CARD TABLE

Schlieren photo shows heat flow about the tip of a soldering iron.

Schlieren Bench Makes Sound Wave, Heat Visible

This simple optical equipment will enable you to actually see sound waves, or heat, or other disturbances in air or fluids

SCHLIEREN OPTICS have been known for a long time. This fascinating technique is not too difficult, nor is the equipment expensive or hard to obtain. By assembling easily available equipment costing only a few dollars, you can explore its vast experimental applications and even record your discoveries on film.

The word schlieren, in German, means "streaks" or "striae," and the optical system it denotes is capable of revealing very small changes and differences in the refractive indexes of gases and liquids. This phenomenon enables you to observe continually changing densities in air or liquid environments.

The air around a hot object such as a soldering iron or flame is in constant turbulence and exhibits changing, invisible areas of high and low densities. A colorless crystal dissolving in water exhibits another kind of invisible turbulence as it diffuses—and again there are localized density changes. A stream of clear water mixing with water that is a few degrees cooler or warmer has its own invisible variable-density turbulence. All such conditions are made dramatically evident by schlieren techniques. The still photographs shown here can only suggest the dramatic fascination of actual schlieren patterns in motion.

Aside from these examples, you can plan many projects using the schlieren apparatus. A little probing of the scientific literature relating to schlieren research will reveal a wide diversity of ideas worth pursuing. Schlieren methods have been used to study crystal growth, analyze sound, and study air layers on the surfaces of textiles; they have been used in medical and biologi-

cal research, and in the testing of lenses and other optical equipment.

The schlieren technique has important industrial research applications in the study of flame characteristics, air jets, etc. Specially modified procedures have even been used to study magnetic fields in tape recording equipment.

Perhaps best known, in terms of published pictures, are schlieren studies having to do with the analysis of shock waves associated with bullets, rockets and supersonic aircraft. Aeronautical researchers have worked out methods by which colored schlieren patterns can be used to obtain important information about density variations in the air surrounding fast-moving missiles or planes. Using this specialized technique, compression patterns in the air are seen in tones of red while expansion patterns are revealed in blue or violet.

Whatever scientific field appeals to you most—biology, chemistry, physics, aeronautics, etc.—you are sure to find many unique applications of the schlieren optics. Let's say you have built a model wind tunnel for aeronautical research. Try using the schlieren technique to observe air-flow patterns around models placed in the tunnel. Comparable experimental applications could be cited in virtually any area of scientific investigation.

The basic schlieren system is really quite simple. A point source of light is focused, by means of a simple lens, onto an optical slit of variable width. The light passes through the slit to a spherical mirror which reflects it (as parallel rays) to a second spherical mirror. The subject to be studied is placed between the two mirrors in the beam of light. The second mirror focuses an image of the subject onto a viewing screen (or camera film if a picture is to be taken) after part of the light has been blocked off by a special optical "knife."

Optical bench. Any type of optical bench can be used provided it has provision to line up, raise and lower, and rotate the various optical elements to get them into proper relationship to one another. You may already have an optical bench, or prefer to con-

▲ *Colorless crystal (arrow) dissolving in water.*

▲ *Clear water from medicine dropper (arrow) flows into cooler water. Note the turbulence.*

struct one of your own design from odds and ends. The one shown here was made from two yardsticks, scraps of metal and wood, and six adjustable curtain rod brackets. The metal brackets serve well because they are sturdy, and can be raised or lowered easily after loosening a single set-screw.

Note that you will need two optical benches, each about 3 feet long. The light source, lens, slit and mirror No. 1 are placed on one bench; the knife and mirror No. 2 are placed on the other bench which must be positioned about 12 feet from the first bench when schlieren experiments are performed.

If you use yardsticks as the bases of your optical benches, select good-quality, rigid sticks. The inch and centimeter markings on yardsticks speed positioning of the optical elements, but you can get by very well with yard-long strips of wood cut from unwarped pine or other available wood.

The support blocks at the ends of the yardsticks have set-screws to keep them in place. The "roving" supports can be quickly slipped on and off for re-positioning without necessitating removal of any optical elements from the yardstick.

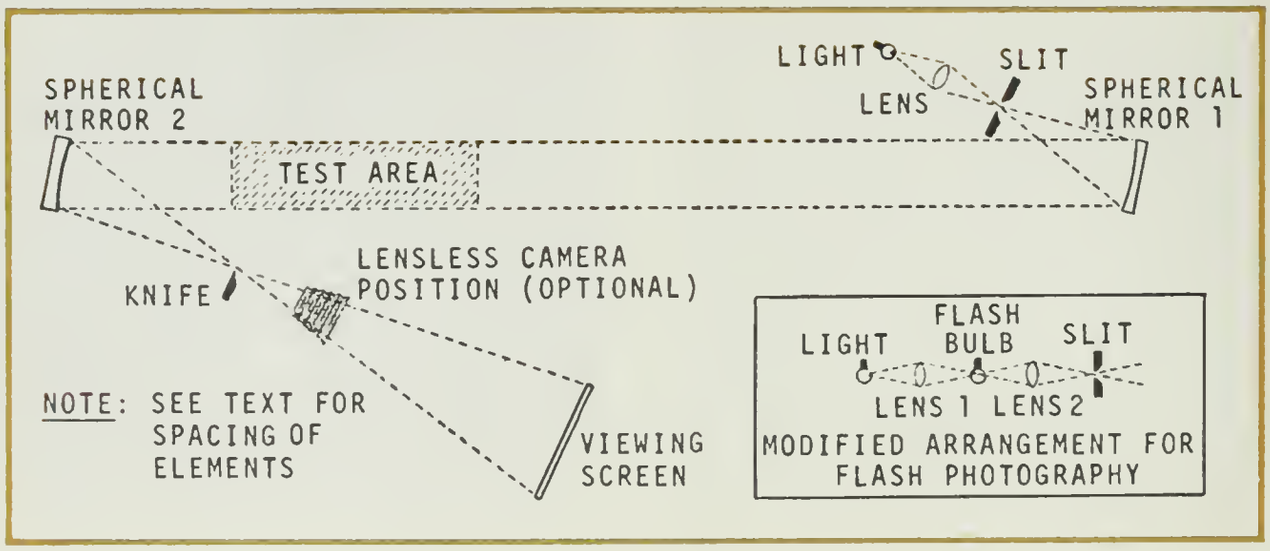
The diagram shows how to convert curtain rod brackets for use on the optical bench. First straighten the hook at the top, then bend this top section to right angles with the main body of the bracket. Sweat solder a 5/8-inch by 3-inch strip of sheet iron—and on top of this a 6-32 hex nut—to the rear part of the bracket base. The metal strip folds under the yardstick, and a bolt through the hex nut passes through a hole in the bracket to tighten the assembly on the yardstick.

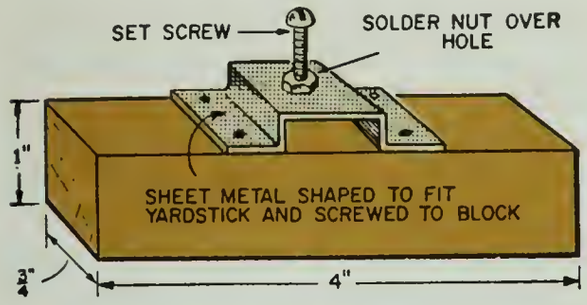
The front end of the bracket is kept from shifting about by dropping 6-32 bolts through the two front screw holes in the base and passing them through plastic or metal tube spacers and then through holes drilled in a short bar made of plastic or metal. The plastic or metal tubing keeps the bar from binding against the yardstick, and also stops lateral sway of the bracket. Lacking suitable plastic or metal tubing, simply wrap some tape around the bolts.

The mirror holders are bolted directly to the tops of their respective brackets, the slit and knife assemblies are attached by means of rigid angle irons, and the light bulb and lens are secured by short lengths of wood dowel. All these methods of attachment permit the units to be rotated.

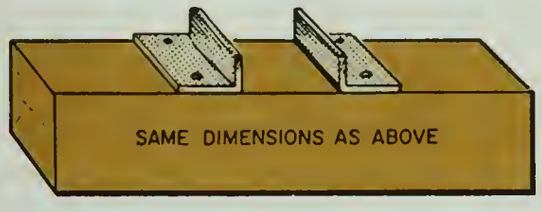
Light source. The light must come from

Basic schlieren system. Use of photo techniques is unneeded.





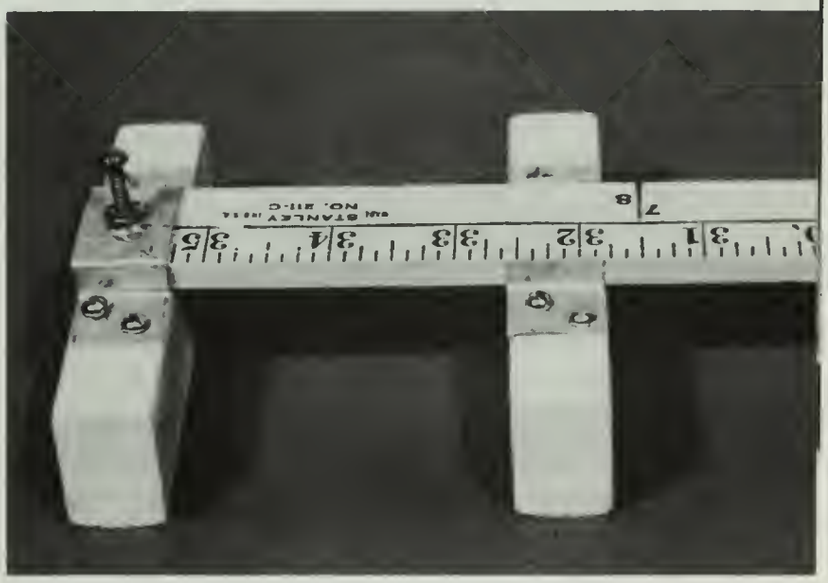
END SUPPORTS (MAKE FOUR)



ROVING SUPPORTS (MAKE TWO)

Details of supports. Note the set-screws that keep yardsticks in place.

Pictorial view of same. Yardsticks should be good quality, or use unwarped strips of wood.



as nearly a point source as is possible. If you own an arc light, use it—you couldn't ask for anything better; the light is intense, and originates from a small area. However, if you do not have arc lights and have little inclination to build or buy one, search about for an acceptable substitute.

Certain types of straight filament projection bulbs (flat ribbon filaments) and some concentrated-arc bulbs are available, but are hard to find and expensive. Much cheaper, and easy to obtain, is an automobile light replacement bulb. Look for a 12-volt, bayonet base, dome-light bulb with a single straight filament coil. Avoid those types that have two filament coils. You will also need a 12-volt transformer (available at radio supply houses) to operate the bulb; or you can use a variable Powerstat transformer.

This source of light is not actually a point source and, therefore, is not ideal. But neither is economy its only virtue. You will be amazed how well this low-priced substitute works. Start your schlieren experiments with this light source and shift to an arc light if you get into more ambitious projects. The auto bulb is bright enough, even after part of the light has been blocked off with the optical knife, to yield bright images of a foot or more in diameter for visual observation. And there is also plenty of light to make photographs using a 1/1,000th of a second shutter speed.

If available, buy a bayonet socket to fit the bulb. If you can't find one, file the locking pins off the base of the bulb, solder lead wires to the base and terminal contact, wrap some electrical tape around the base and push it into a 1-inch length of electrical conduit or other metal tubing.

Mount the bulb on the end of a wood dowel and make a light shield for it out of sheet metal. Do not use a reflector which would tend to diffuse the light. The open shield eliminates most glare and permits air to circulate freely to keep the bulb cool. Any objectionable light spillage onto other parts of the equipment can be shielded with a piece of cardboard.

Lens. Almost any short focal-length lens available (2 to 3 inches is ideal) that can form a sharp image of the bulb filament can be used. A simple double-convex magnifying glass will do. An old camera lens with

a 2-inch focal length was used here. Mount the lens on a wood dowel.

Mirrors. You will need two spherical mirrors which should be at least 7 inches in diameter. Ordinary flat mirrors will not do because they cannot focus the light properly. Two 7-inch magnifying shaving mirrors, are satisfactory. Smaller sizes are available, but they are not recommended.

Remove the wire stands that are attached to the mirrors and replace them with new holders bent from some stiff strap metal. Projecting 6-32 bolts fastened to the ends of the brackets slip into the holes in the mirror frame. Remember to clean the mirror carefully before starting schlieren experiments.

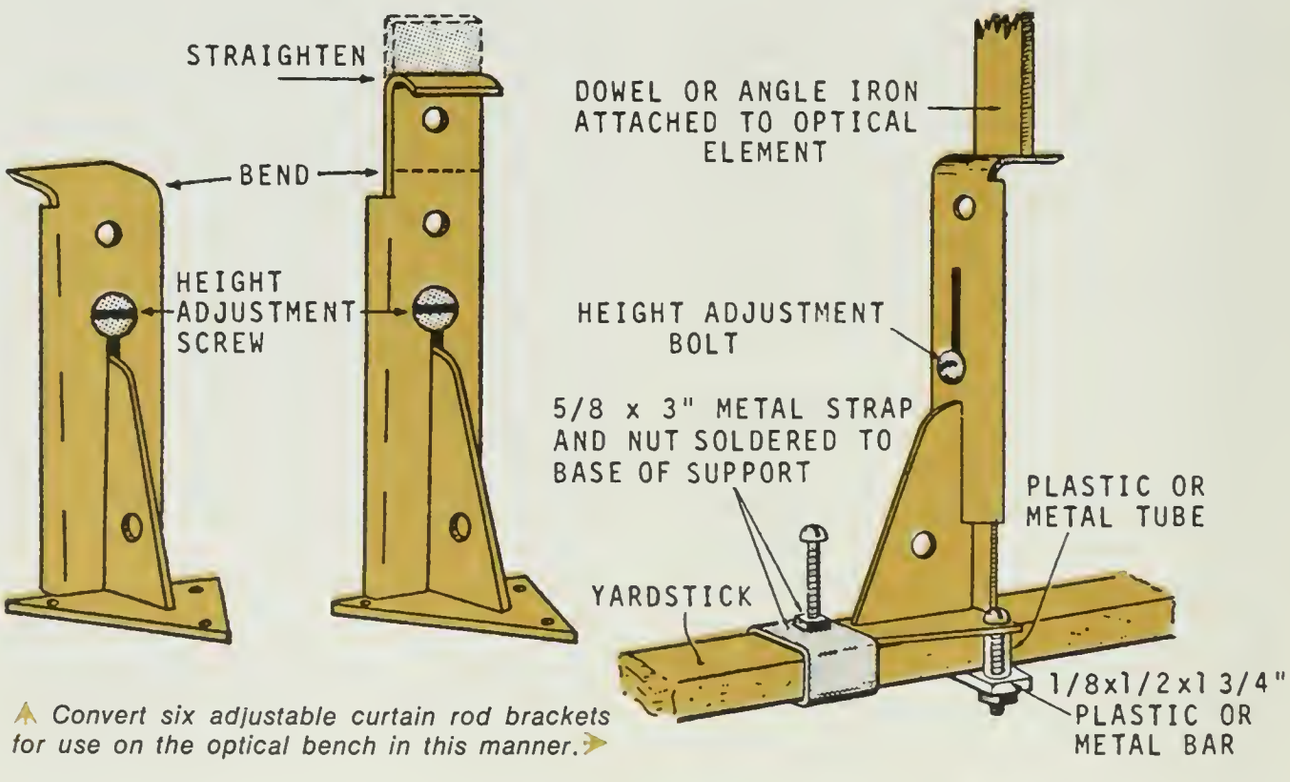
Optical slit. You can short-cut the construction of the adjustable optical slit by simply cutting a ¼ x 1-inch vertical slot in the middle of a ⅛-inch thick Masonite panel (about 8 x 8 inches). Tape two new single-edge razor blades over the slot so that their sharp edges form a slit about $\frac{1}{16}$-inch wide. However, this makeshift slit does not have the manipulative flexibility offered by an adjustable slit. If you build the more versatile slit, chances are you will ultimately use it in other types of optical experiments.

The slit described here is admittedly not a precision instrument of the same caliber sold, at high prices, for critical scientific work. But it serves well and has the advantages of low cost and ease of construction.

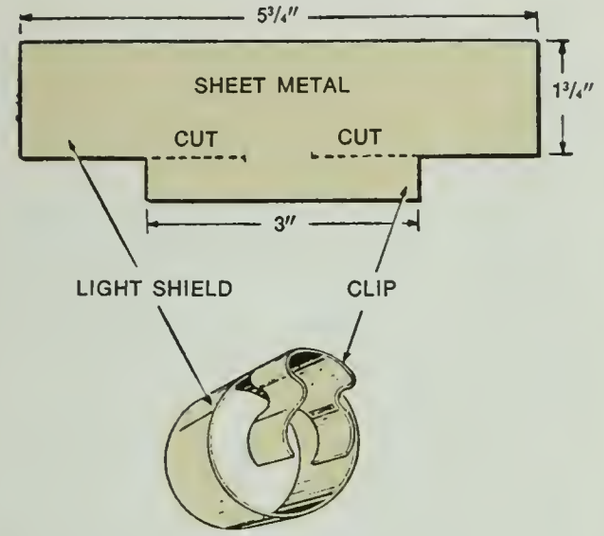
Cut the six ½-inch wide moving arms from stiff sheet aluminum or iron, and lay out the hole positions carefully. Mark all hole positions with a center punch, before drilling, to insure accuracy. Small aluminum rivets are used to join the arms together; these should be hammered down just enough to eliminate any wobble while leaving the arms free enough to pivot smoothly.

New single-edged razor blades are riveted firmly to the horizontal arms; the blades already have convenient center holes for this purpose.

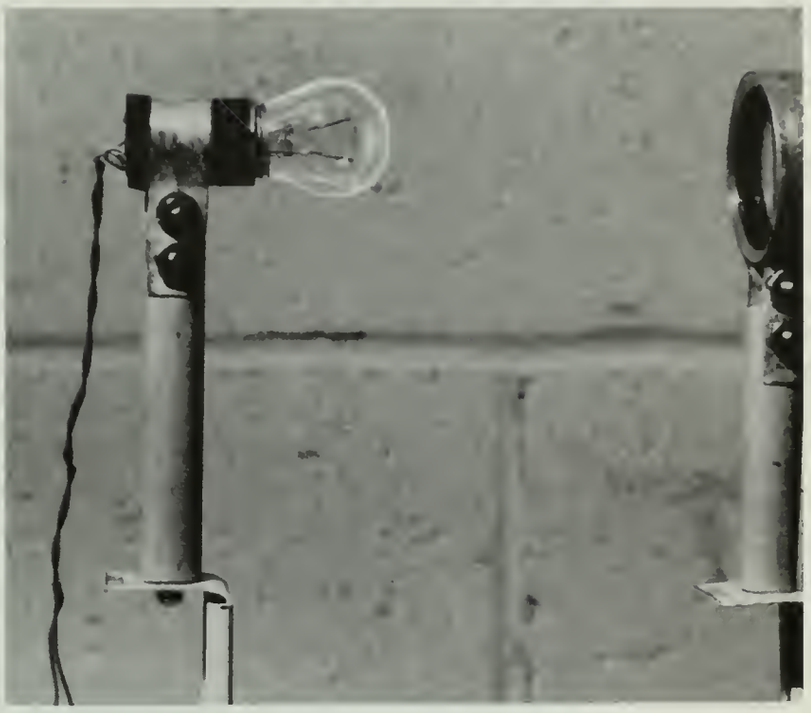
The two "pivot rivets," (split rivets), extend through the Masonite panel to hold the arm assembly on the board. These, too, should be tightened just enough to prevent


STRAIGHTEN
BEND
HEIGHT ADJUSTMENT SCREW
DOWEL OR ANGLE IRON ATTACHED TO OPTICAL ELEMENT
HEIGHT ADJUSTMENT BOLT
5/8 x 3" METAL STRAP AND NUT SOLDERED TO BASE OF SUPPORT
PLASTIC OR METAL TUBE
YARDSTICK
1/8x1/2x1 3/4" PLASTIC OR METAL BAR

Convert six adjustable curtain rod brackets for use on the optical bench in this manner.



▲ *Sheet metal light shield for bulb.*



➤ *Dowels, metal straps mount bulb and lens. Upper, tightening bolt bypasses dowel.*

wobble but not so much that rotation of the arms is impeded.

The angle iron at the top of the arm assembly, which is attached to the adjustment bolt, is also made from flat sheet metal. Bend it so that it rides against the Masonite panel. Note that the two rivets do not pass through the metal arm which must be free to move up and down; the rivets are placed next to the arm with the shanks touching the arm edges and the heads overlapping the arm.

A small angle iron is also bolted to the top of the panel, with one leg projecting forward; a suitable nut is soldered over a hole in this leg. The adjustment bolt is threaded through the nut until its end passes through a hole in the top end of the moving arm. Washers are soldered to the bolt, one on each side of the moving arm. These washers push and pull the arm when the adjustment screw is turned.

The razor arm channels can be made from wood, metal or plastic. Plastic is preferred because it is easily drilled and shaped, and because the razor arms slide easily against its surface. In any case, construct and position the channel blocks very carefully so that they guide the razor arms without binding and with a minimum of side-play. Cut a ¼ x 1-inch slot in the middle of the Masonite panel.

To assemble the unit, lay out the prejoined razor blade-arm system on the board, positioning the blades accurately over the opening and checking to see that the vertical moving arm and adjustment screw line up accurately. Tape the parts to the board while drilling the two pivot holes and the bolt holes for the channel blocks.

Optical knife. Construction of the optical knife is shown in the diagrams. Three ⅛-inch-thick Masonite panels, measuring approximately 3½ x 4¼ inches, are bolted together with 6-32 bolts after an arced notch has been cut into the top of the middle panel. Bolt an angle iron to the bottom (rear) of the Masonite sandwich to fasten the unit onto one of the optical bench brackets.

Cut a 1-inch square hole in the center of a Masonite disc, 4 inches in diameter. Fasten a single-edged razor blade onto a sheet metal arm, as shown, and fasten this

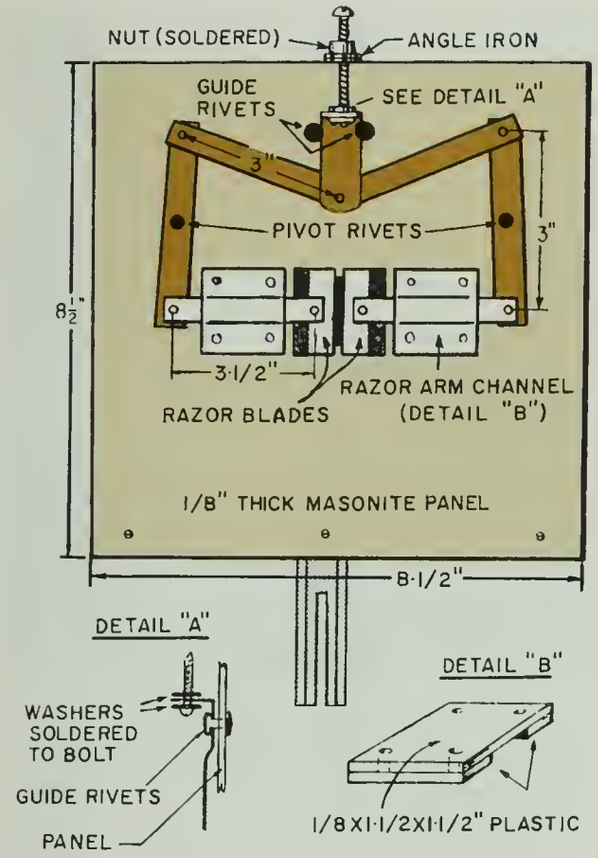
▲ *Top bolt moves arms. Razor blades are blackened.*

▼ *Light source (shade removed), lens, adjustable slit, mirror in approximate positions. Transformer is unseen.*

arm to the disc with four split rivets. Note that the rivets act as guides and do not pass through the arm itself. When the completed disc assembly is dropped into the Masonite pocket, it can be rotated through 180°.

Viewing screen. You can perform schlieren experiments without the adjustable ground-glass viewing screen by projecting the image onto white paper. But you will soon see why a ground-glass screen is a near necessity.

The schlieren equipment extends for some 12 feet because the mirrors must be spaced several yards apart. It is often necessary to view the image from two sides of the ground-glass when the various optical elements are being aligned. The adjustable support is convenient because the glass can be quickly shifted up or down to keep the image properly centered on the glass. The dimensions are not critical, and you can use a ground-glass sheet of almost any size (preferably larger than the one shown). If a piece of ground-glass is not readily available, a piece of translucent acetate sheet, obtained from most art supply stores, will do.



Adjustable optical slit details.

Experimental procedure. The photographs show the approximate positions of the optical units on the first bench. The exact positions will depend largely on the focal length of your lens; you will have to work out the proper space relationships according to the procedure described below.

The second bench holds a mirror at one end and the optical knife approximately 2 feet away from the mirror. The ground-glass screen is generally positioned, independently, several feet from the optical bench.

Position the optical benches parallel to each other so that the mirrors (turned slightly in their mounts) face each other and are about 12 feet apart. Although the distance is not critical, it should not be less than 10 feet.

Check the light bulb to see that its filament is in a vertical position. Close the slit, or tape a thin piece of paper over it temporarily, while making the next adjustment.

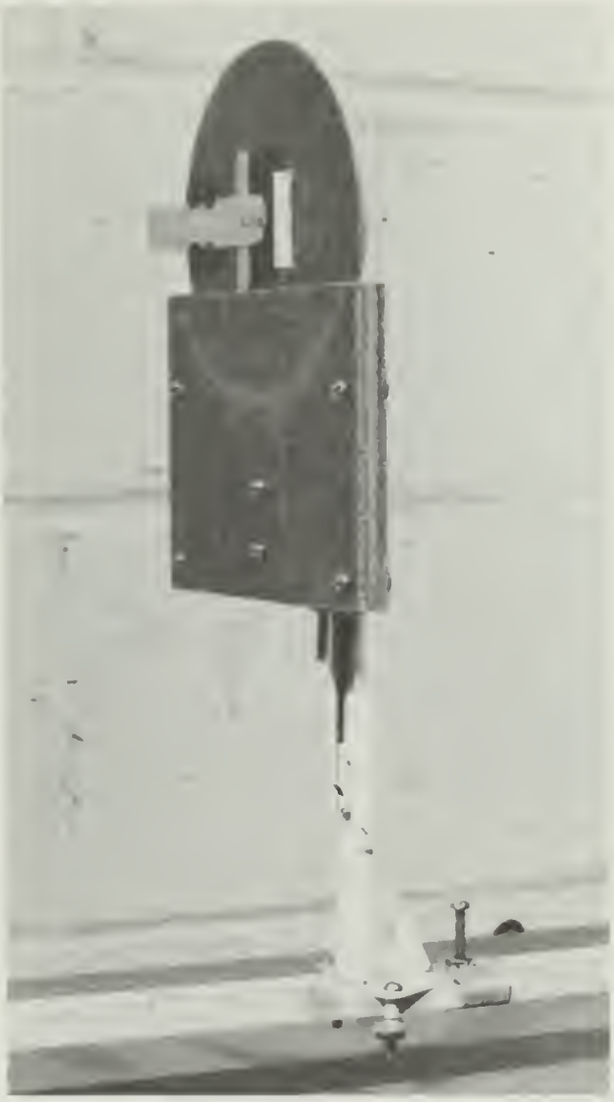
Starting with the lens fairly close to the bulb, move the lens and slit mountings, alternately, away from the lamp until you get a clear image of the lamp filament on the slit. Twist the lamp mounting, if necessary, to accurately align the filament image with the slit. Remove the paper from the slit, and open the slit to let the light fall on mirror No. 1. Raise or lower the various elements until the light hits the exact center of the mirror. This operation is easier if you aim the mirror so that the light is bounced back through the slit onto the center of the lens. The mirror functions best when placed so that it is its own focal length away from the lens. (To find the focal length of the mirror, focus the sun's image on a piece of paper, then measure the distance from the mirror to the paper.)

After these preliminary adjustments have been made, turn the mirror so that it throws a parallel beam of light onto mirror No. 2. This second mirror is turned so that it beams the light onto the ground-glass screen, positioned about 6 feet away.

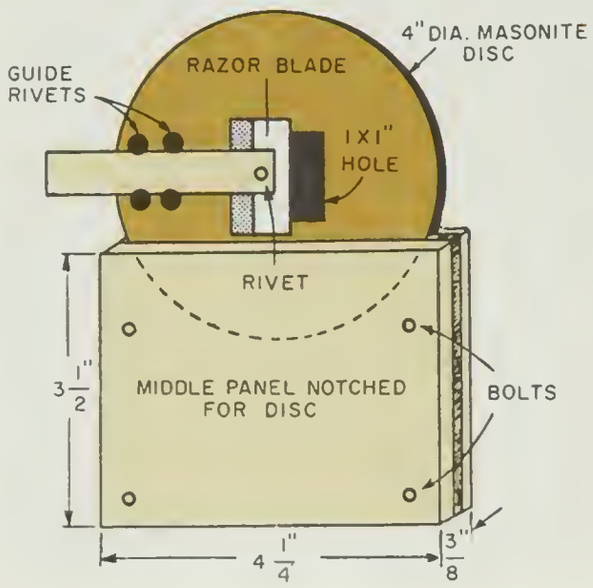
Arrange the two optical benches so that the beams of light are angled no more than necessary to send them through the optical elements. Excessive angling increases image distortion.

When all the optical elements are properly aligned, and a bright spot of light appears on the screen, locate the subject test area. The best position for the subject to be studied depends on the position of the viewing screen (or camera). A quick way to find the position of sharpest focus is to move a piece of wire mesh screen back and forth along the parallel beam of light, observing what position provides the sharpest image on the ground-glass. Place your subject (e.g. flame) at this spot. If you change the position of the viewing screen, you will have to relocate the test spot.

Incidentally, you will get a brighter image



Optical knife. The razor blade "knife" can be moved back and forth across square hole. Disc rotates freely when dropped into pocket.



if you place a piece of white cardboard over the ground-glass. Remove the cardboard when you need to view the image from the back side of the ground-glass.

Having found the best subject position in the test area, place a lighted candle or alcohol lamp at that spot. You should now see a clearly projected image of the flame on the screen—but you will not yet see the full schlieren effect. A critical adjustment of the knife must first be made.

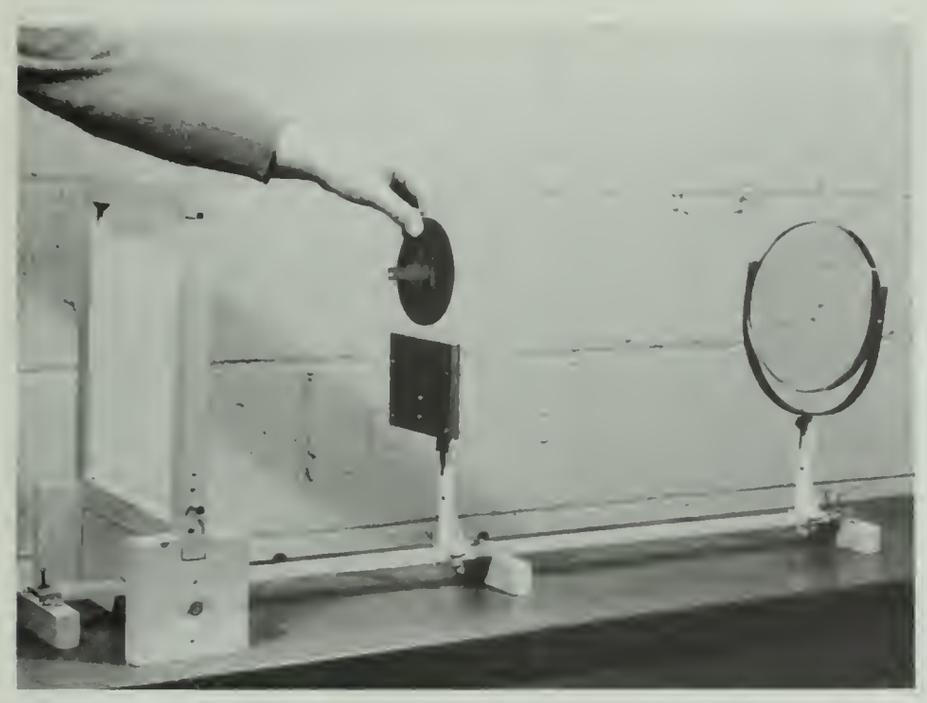
Move the knife so that it covers the hole in the disc, and the light falls on the blade surface, which should be blackened. Move the knife unit back and forth along the optical bench to focus the sharpest possible image of the slit on the knife. If the image does not seem bright or sharp, check alignment of all elements, starting with the light source. Make certain the light passes properly through the slit. Vary the slit width if necessary.

When you have a sharp image of the slit on the knife surface, move the knife aside until about half of the light is passed to the screen and the other half is blocked by the knife edge. You should see a thin, bright line of light along the blade edge. The disc holding the knife may need to be rotated to obtain proper alignment.

Don't expect perfect results immediately. The adjustments are delicate, and you will have to get the feel of the equipment. Keep re-checking all elements until you get an image containing bright areas and deep black areas. When the system is working well, log the positions of all elements so that you can set up the equipment speedily next time.

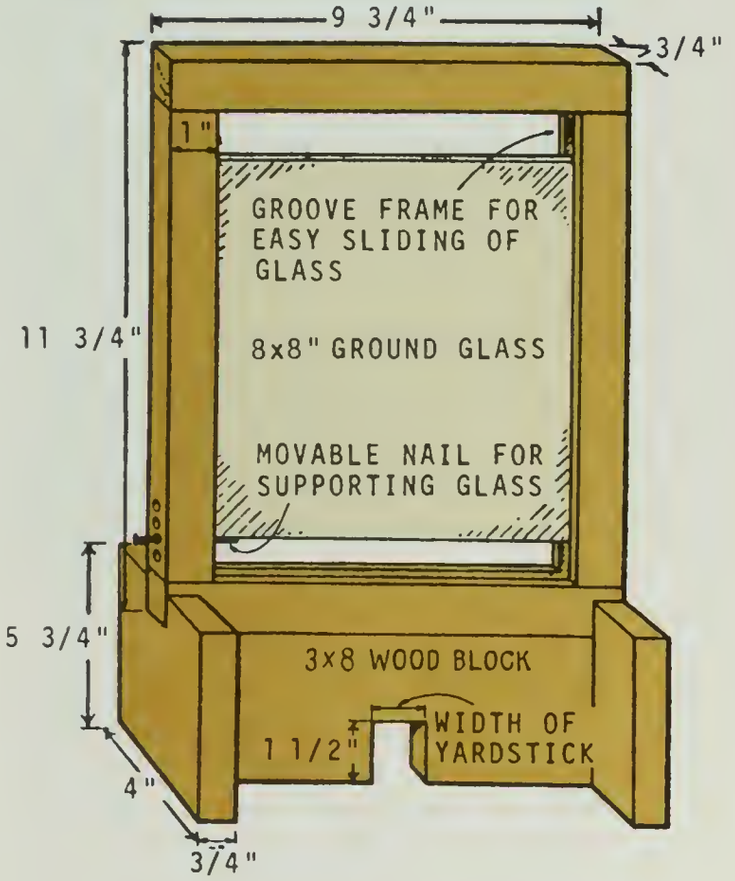
Schlieren photographs. A modified lighting system can be used to take schlieren photographs using flash bulbs. Do not use ordinary wire-filled, combustible bulbs; the light would be too diffused to yield good images. A GE-type FT 230 flash tube would suit your purpose.

It is quite possible to obtain good pic-



Disc holding "knife" goes in pocket of holder-light shield. Screen is used farther away.

Construction details of ground-glass viewing screen. Image can be seen on white paper.

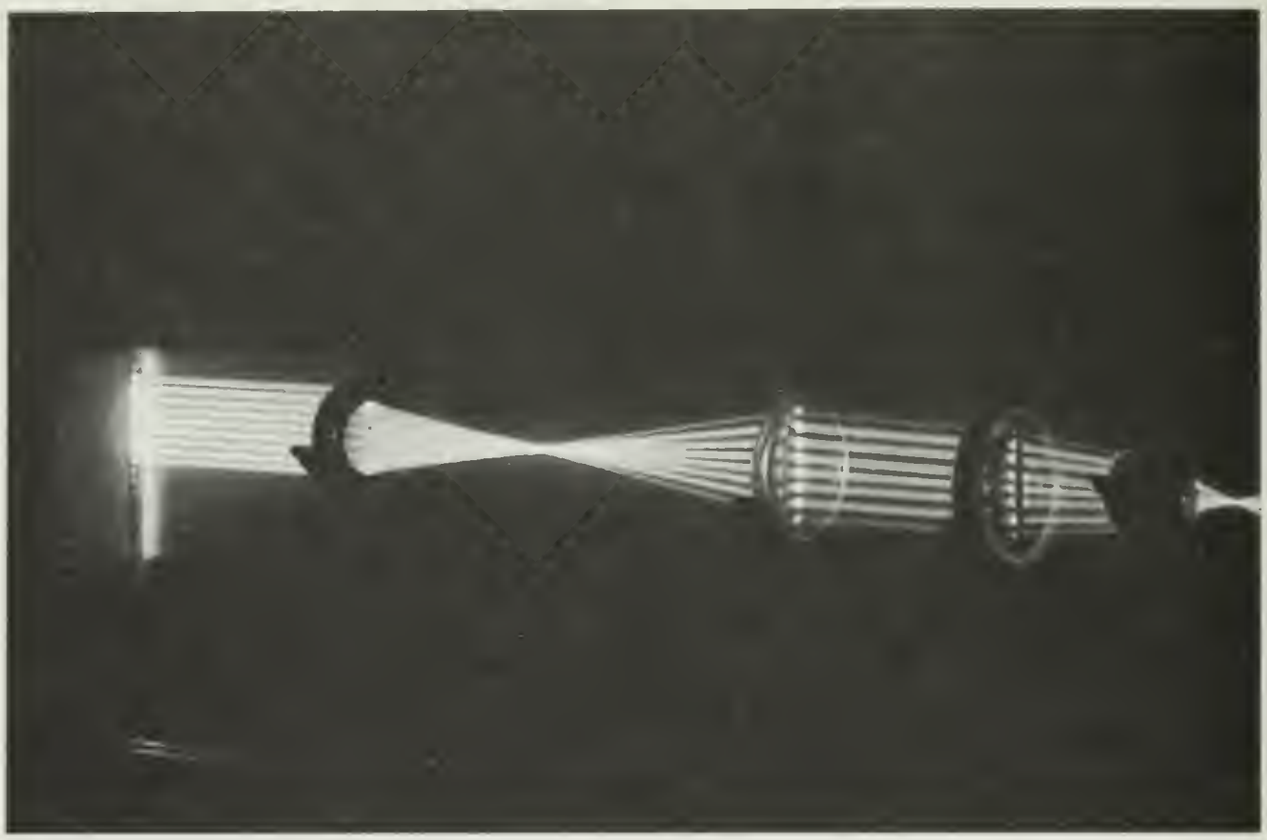


tures with the basic setup alone, without using flash bulbs. In fact, the photographs shown here, were made without supplementary lighting. They were made with a 35mm single-lens-reflex camera loaded with Tri-X film. After removal of the lens, the camera was placed about 12 inches from the optical knife.

The subject (soldering iron, crystal, water jet) was moved back and forth in the test area of the light beam until a clear image was observed in the camera viewfinder. The camera shutter was set at its fastest speed (1/1,000 second) in order to stop the fast motion of the schlieren image. The very short exposure notwithstanding, there was plenty of light to produce good negatives on development of the film according to normal procedures. In these experiments, the fast shutter speed was used primarily to demonstrate the adequacy of the light. You may find much slower speeds adequate.

If you have a movie camera, you might try shooting with fast black and white film to capture the schlieren patterns in motion. You may wind up with some fascinating footage. However, the schlieren technique does not require the use of photographic procedures in any form. The patterns can be observed visually on a simple cardboard or ground-glass screen. J.H.

See also: PHOTOMICROGRAPHY.



▲ *Parallel light rays, clearly seen in smoke, dramatically show lens characteristics.*

See How Lenses Work with a Smoke Box Optical Bench

This device you can make yourself will enable you to construct telescopes or other optical equipment, even before you learn to use lens formulas

YOU FLICK A SWITCH. Instantly, brilliant shafts of light leap into a pitch black box, crossing and recrossing each other in their luminous passage through a series of lenses. A final minor adjustment of one lens, then a few quick readings taken from the meter stick on which the lenses are mounted. You are now ready to put those lenses together to make that new telescope you have wanted. Or perhaps it is some other optical device you are making—a microscope illuminator, a colorimeter, or a slide projector.

With the aid of your newly built optical smoke box, you don't hesitate to tackle new projects involving the use of lenses, mirrors, prisms, optical slits, diffraction gratings or other optical elements. You no longer have to wonder which lens is out of place. It is obvious at a glance because the light passing through the lenses is clearly visible every inch of the way, from one end of the experimental optical system to the other.

There's no guessing about the position of the focal point of a lens; you see it. To calculate the angular dispersion of a beam of light by any given element simply put a protractor up to the light beam and measure it. How much light is lost, and in what directions, through secondary reflections of

a prism? You clearly see the vagrant rays as well as the primary rays. You suspect that one lens is less than perfect, and that it might work better if it were slightly skewed off its theoretically correct alignment. But how much, and in what direction? Lens formulae won't help here. But the luminous rays in your optical smoke box will provide the answer quickly and easily.

You can start building useful optical gadgets long before you acquire a sophisticated knowledge of optics mathematics. In fact, the optical smoke box is so much fun to use, and so graphic in its demonstration of what lenses, prisms and the like do to light, that your comprehension of theoretical optics is bound to increase faster than you thought possible.

How it works. An optical bench consists of a long horizontal "bed" marked off in inches and millimeters. Clamped to this bed are a number of adjustable supports for holding lenses and other optical elements in accurate alignment so their combined effects on a beam of light can be studied.

This basic bench is an extremely useful piece of equipment, but it has one limitation. You cannot see the actual passage of light through the lenses, or at intermediate points between them; you only see the final result of their combined influences in the form of an image projected onto a target panel.

Have you ever noticed the burst of sun "rays" that appears when the smoke of a campfire or burning leaves filters through a sunlit tree? Perhaps you have pointed a flashlight into the sky on a foggy night and watched the long, luminous beam stretch into the distance. In much the same way, you can make the light traveling along an optical bench visible.

The trick is to build the optical bench into a closed box having an observation window on one side, then fill the box with finely dispersed smoke. The smoke scatters the light just enough to make the light rays clearly visible.

Basically, it's as simple as that. But the design of a really efficient smoke box calls for more thought and planning. You must devise a way of producing as nearly parallel light as possible, and then send it into the box in the form of thin, parallel rays, distinctly separated from one another. This can be tricky. However, if you carefully follow the directions given here, you will be delighted with the results.

The optical bench. You will save a lot of time and labor, and finish with a more serviceable instrument, if you buy the optical bench part of this equipment ready-made. The bench shown here consists of a rigid meter stick, two metal supports (one with a reticle, the other with a first-surface mirror), and four fully adjustable metal lens holders.

If economy is a prime consideration, you can make your own, if you are mechanically inclined. Buy a sturdy meter stick that is graduated in millimeters on one side and inches on the other. Devise a number of lens supports that can be slid along the length of the meter stick.

You should be able to move the lenses up and down, and also rotate them, while keeping them aligned over and along the length of the meter stick. Small wooden blocks grooved to slide on the meter stick might serve as the bases. Fit these with short lengths of wooden dowel that can be slid up and down through holes drilled into the blocks. Provide some sort of clamps on the ends of the dowels to hold the lenses.

It can be done. However, it would be wiser to buy the optical bench and effect savings in other ways. For example, make the smoke box from corrugated cardboard instead of plywood, and use household plastic wrapping tissue for the window instead of the sheet plastic shown. The prototype model of the refined equipment was

▲ *Complete assembly consists of slide projector light source, lens box, smoke box.*

constructed that way, and it worked very well. But it doesn't look "professional" and won't last as long as a well-built job.

The smoke box. The easiest way to build the big smoke box is to start with the end pieces shown in the drawings. They are identical in size, and have identical openings at the same heights.

The reticle panel, which will become the left end of the box, has two vertical strips of wood on either side of the opening. Three narrow grooves are cut lengthwise, along the inside sections of the strips. The reticle plate and two cardboard baffles will slide up and down in these grooves.

The opening in the hatch end will be closed with a lid made from two slabs of plywood, as shown. The smaller slab is of ½-inch thick material, the larger of ¼-inch plywood. A small knob in the center (not shown) will make it easy to remove and replace the lid.

No dimensions are given for the meter stick notches because they should be made to fit the actual meter stick used. Be sure the notches are both perfectly vertical, and that they hold the ends of the meter stick snugly, but just loose enough that the stick can be removed for turning over to make the rear scale visible when desirable.

Connect these end panels together by fitting the meter stick into the notches. Place the assembly on the bottom panel which is cut slightly oversize from ½-inch thick plywood. Carefully check that both panels are square with the front edge of the bottom panel, and perfectly vertical. Hold in place temporarily with braces made from strips of wood. Mark the exact size of the bottom. Cut and fit the ends to the bottom, using glue and nails or screws. Once again, check that the end panels are perfectly vertical, and then fit a rear panel made from ¼-inch thick plywood.

The window frame is made from ¾ x 1-inch strips of wood. Grooves just large enough to accept the thickness of the glass

or plastic window material you use are cut into the ¾-inch inside edges.

A sheet of acrylic plastic is probably the best material to use because it is clear, rigid, and shatterproof. If you can't buy the plastic locally, use thin window glass or even clear acetate sheet which is available at art stores.

After a preliminary fitting to see that the window will fit properly into the frame without skewing the end panels out of vertical alignment, fasten the lower strip in place with screws through the end panels. Put the vertical end strips in place, add the window, and lock in with the top strip.

The top of the box consists of ¼-inch or ⅜-inch thick plywood cut to size. Use ½ x ¾-inch strips on the underside to hold the lid in place.

Cut a 9 x 1¾-inch hole in the center of the top panel. Rabbet two strips of wood and make a sliding track for a glass or plastic window under the lid, as shown. Make a small lid to fit the hole to keep out light when it is not used. Make this from two slabs of plywood, in the same manner as you made the lid for the hatch end panel.

This sliding window will enable you to look down on the light beam to check its width and alignment. You may want to open it to blow into the box to disperse the smoke, or to shine auxiliary light beams into the box from above.

The photograph shows the plastic curtain that is hung below the window to permit ready access to the interior of the box. The drawing shows how three sections of flexible polyethylene film (from an old shower curtain) are stapled to the back of a strip of wood which is then screwed to the lower edge of the window frame.

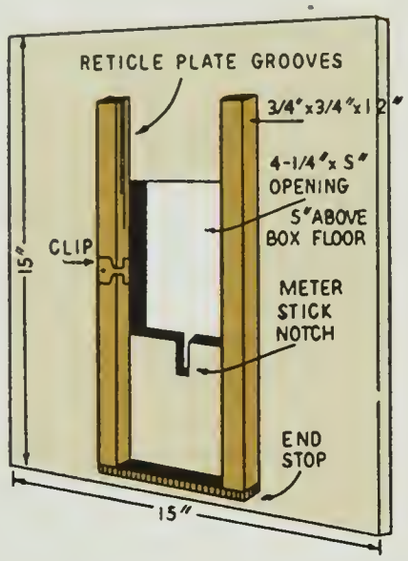
The curtain makes it easy to reach into the box to adjust the lenses. As soon as the hand is withdrawn, the curtains close to keep the smoke from escaping.

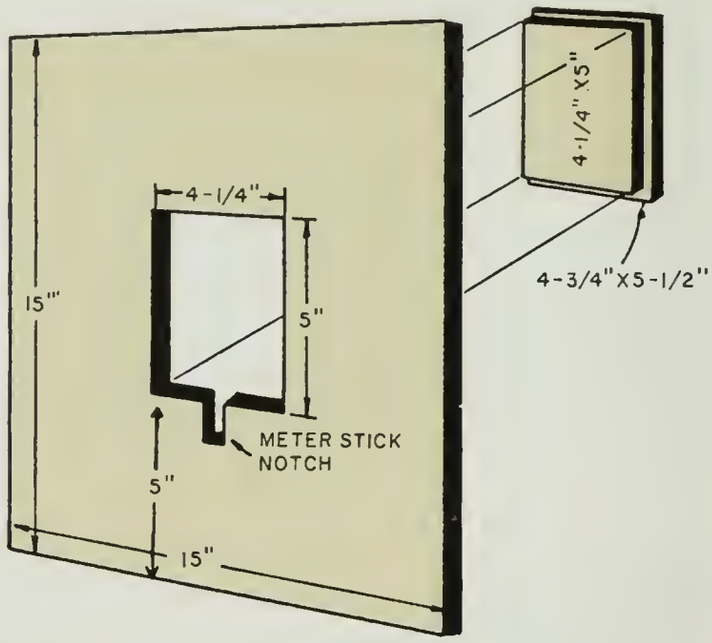
The inside bottom, sides and top can be painted with flat black paint. However, you should paste velveteen onto the rear wall because it provides a far blacker background than you can obtain with paint. The velveteen is fairly expensive, but you don't need much and it is worth the outlay. If you plan to take photographs of the lighting set-ups, velveteen is a virtual necessity. Library paste will hold the cloth in place.

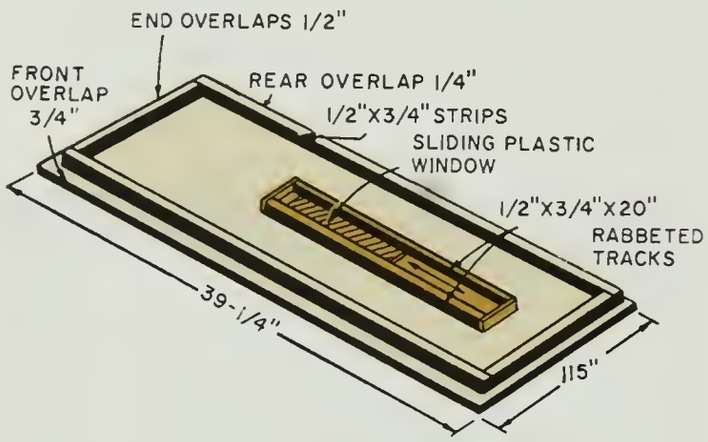
The parallel light problem. The drawing shows how the thin light rays should ideally extend, unchanged in thickness, from one end of the box to the other. In practice this is almost impossible to achieve. You would have to have a beam of light with perfectly parallel rays that could be directed at the reticle and strictly parallel light can be obtained only from a very distant source like the sun or from a point source. But the mo-

Reticle plate panel on left of smoke box. Holed metal plate slides along wooden track. Cardboard overlap (top) blocks extraneous light. Lower cardboard has one hole to permit selection of single rays. Metal clip keeps the lower card from sliding.

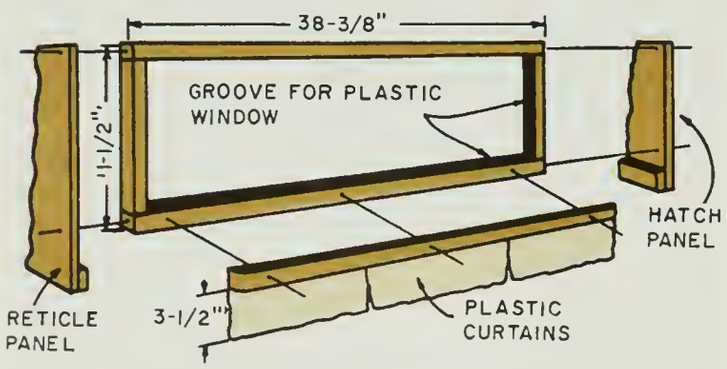
Hatch panel details. Start construction with end pieces illustrated here.







Detail of underside of cover of the smoke box. Plastic window slides in tracks.



Front assembly detail. Grooves for glass or plastic window are cut into 3/4-inch inner edges.

ment you construct a lamp filament large enough to emit any appreciable amount of light, you no longer have a point source.

You must therefore compromise to achieve an acceptable degree of parallelism along with adequate light intensity. Consequently your rays of light will be slightly conical as shown in the drawing. The optical system used in this equipment will not hold you rigidly to one set compromise. But, as will be explained later, you can at will increase light intensity at some sacrifice—usually negligible—in ray parallelism. If your rays in the left half of the smoke box are as clean cut and parallel as shown in the photograph, your rig will function to your complete satisfaction.

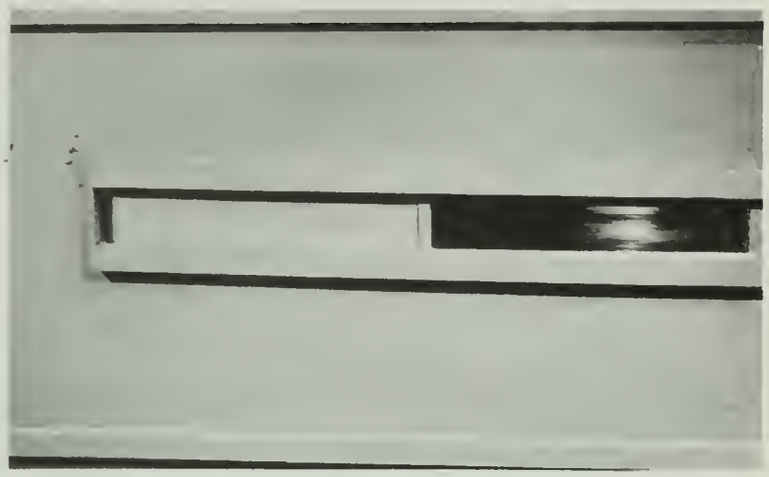
Some how-to-do-it science manuals sug-suggest that parallel light can be obtained by the simple expedient of removing the objective lens from an ordinary slide projector. This is fine in theory, but the light is far from parallel in actual practice. One solution is to put the projector as far as possible from the reticle, but this reduces light intensity too much.

Lens box. The lens box shown in the drawing will modify the projector light enough to make it wholly satisfactory with

respect to parallelism and intensity. The essential part of the unit is the long box which must be mounted at such a height that its open right end is at the same level as the holes in the reticle plate. A sleeve made from a cardboard mailing tube is attached to a hole on the opposite end; this fits snugly into the lens barrel of the projector. If you have a more modern projector of different physical design, you will have to modify the base in some way to get the projector to the proper height.

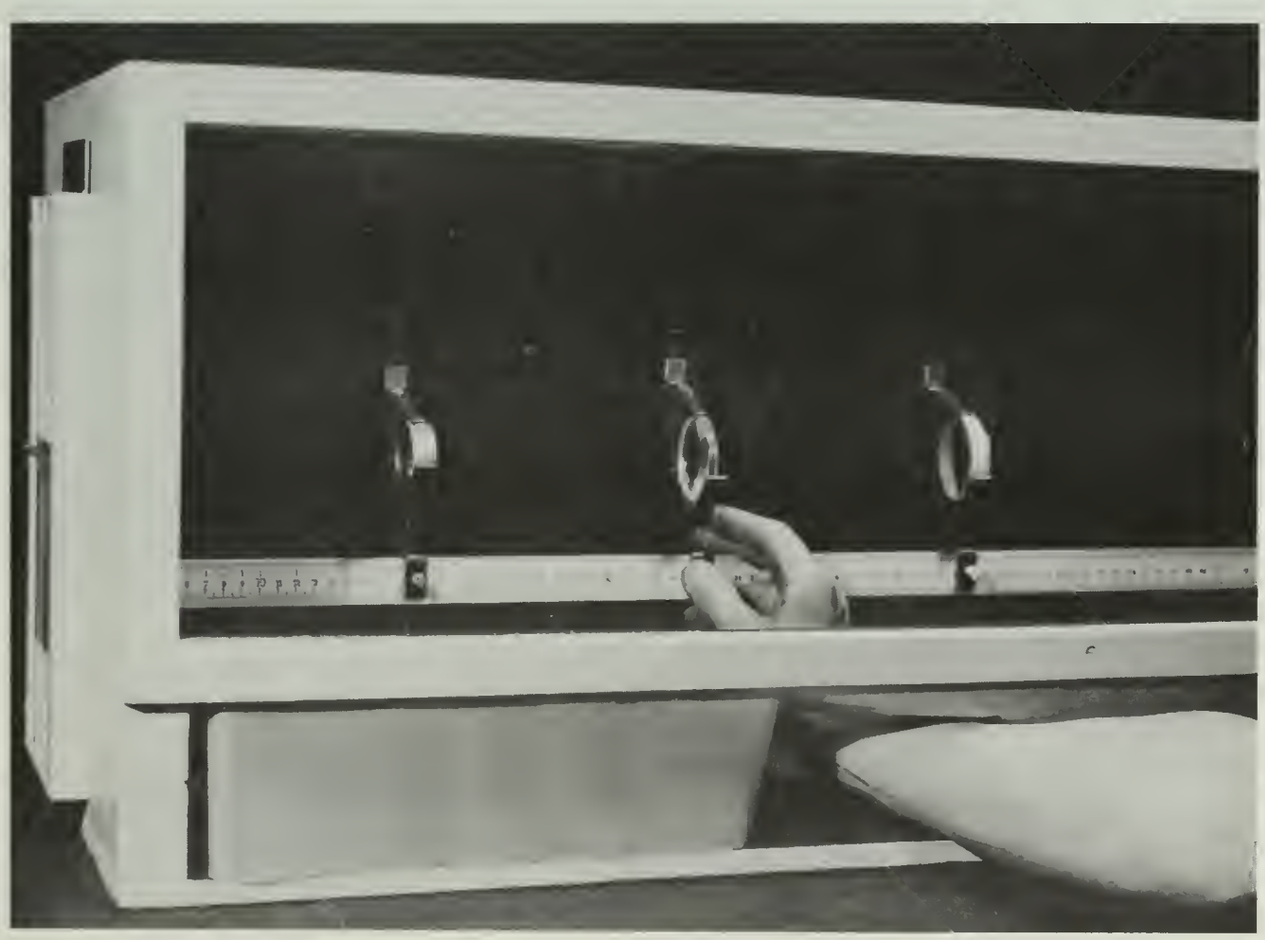
The objective lens of the projector simply drops into the front end of the lens box. A small supplementary lens in a wooden, moveable holder is placed near the rear of the box.

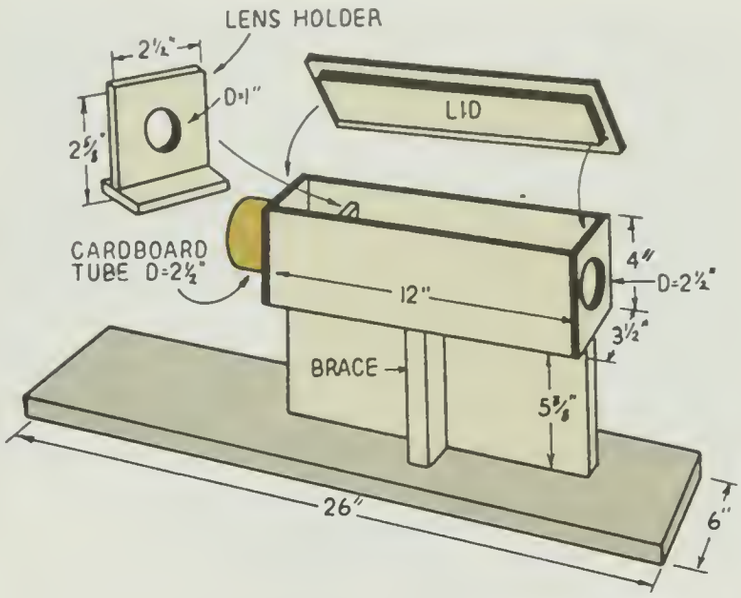
A 1-inch diameter double-convex lens of about 1¾-inch focal length will work well in this system. You may have to experiment a bit if your equipment is different, but you shouldn't have too much trouble.



Photographic view of smoke box lid's underside showing track for sliding window. Cover atop box closes window when unused.

Three-section plastic curtain permits easy insertion of hand to make lens adjustments. The smoke will not escape from box.





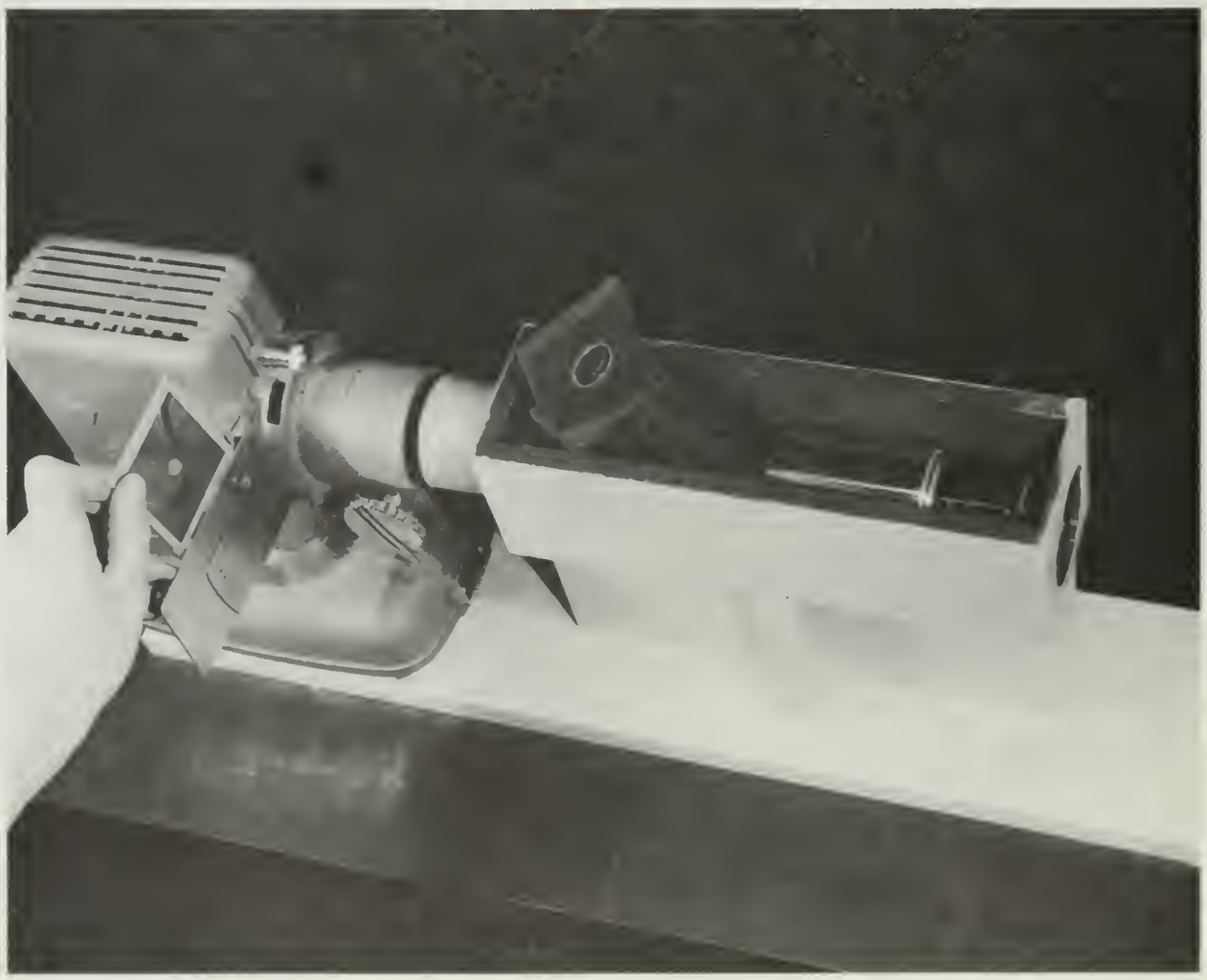
Projector lens drops into front of lens box. Note construction of small lens holder. A hole cut in black paper and mounted between glass forms aperture slide placed in projector slide carrier. Cardboard slides into lens barrel.

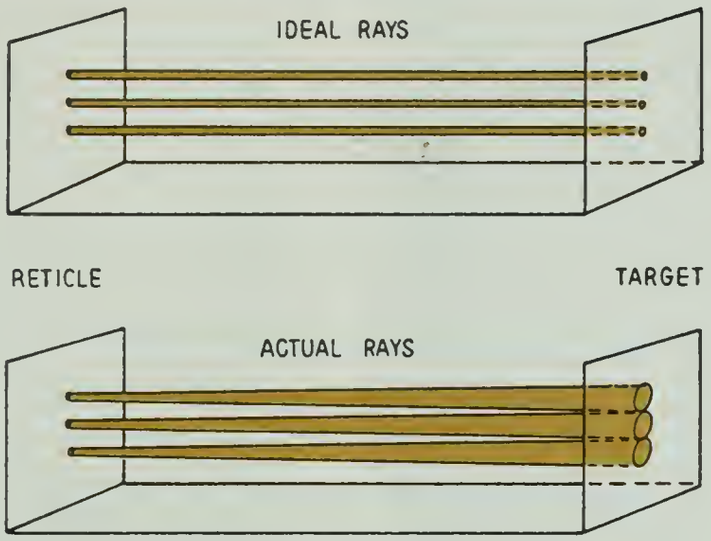
If the projector and lens box are unitized as shown, it is a simple matter to butt the base board against the end of the smoke box to obtain the right spacing of all elements, including the lens to reticle distance.

The 300-watt projector used with this equipment gives wholly adequate light. If you happen to have a 500-watt projector, your illumination problems will be simpler.

Note the aperture slide being inserted into the projector slide carrier in the drawing. It is essential that you reduce the area of the light source as much as possible. Here is where the extra power of a 500-watt projector would help. You could use a smaller aperture without sacrifice of ray intensity, but with a distinct gain in the parallelism of the rays in the smoke box.

One experimenter has a number of interchangeable slides with apertures rang-





▲ *Parallel and conical rays. The ideal are near impossible to get.*

ing from 3/32 to 3/4-inch in diameter. The one most frequently used has an aperture of 3/8-inch. These slides may consist of black cardboard with holes of various sizes cut into their centers. They are bound between sheets of glass to make them more durable and heat resistant.

Reticle and accessories. If you buy an optical bench, you will have a reticle ready-made. Just slide it into position along the innermost track of the reticle panel. There will be objectionable light leakage above the metal reticle plate unless you add a black cardboard light baffle. It is simply a piece of black poster cardboard cut just wide enough to slide down the same track as the reticle; add a slightly narrower tab on the end of the cardboard so that it overlaps the top edge of the reticle plate.

Another black square of cardboard is dropped to the bottom of the outermost track. This has just one hole in the center —3/32-inch in diameter. The cardboard can be slid up over the reticle plate to block off all reticle holes except any chosen one. In this way it is easy to isolate any one ray and observe its passage through the various lenses being tested.

If you make your own reticle plate, start with a rigid piece of sheet metal, 4½ inches wide and 6 inches high. Draw a line lengthwise, down the middle, then drill about ten 3/32-inch diameter holes along the line, spacing them 5/32-inch apart on centers. Your plate should look much like the one in the photograph.

Some ready-made optical benches also include another metal plate with an attached first surface mirror. This can be mounted on the meter stick and slid along it for use in measuring the focal lengths of lenses. The kit includes directions on making such measurements.

You may have wondered about the purpose of the rectangular opening in the right end "hatch" panel. This is to give you more elbow room if the box isn't long enough to handle a particularly long optical system. Just remove the door and let the beam pass through to an external target, or wherever you wish.

Mount an electric bulb base in the top front corner of the hatch panel and wire it to a switch accessible from the outside. It is handy as a utility light when adjusting lenses or when you want to check distance readings on the meter stick.

Smoke generation. One of the best sources of fine-particle smoke is incense. You can buy it at novelty stores that deal

in Japanese imports. Some brands are outrageously overpriced, but you should be able to pick up a box of 50 pellets at a nominal cost. Burn one of these on an ash tray inside the box, and you will have plenty of excellent smoke for a long experimental session. Tobacco smoke also works.

Alternatively you can make so-called "touch-paper" by soaking mimeograph or similar non-glazed paper in a 5% to 10% solution of sodium or potassium nitrate. When dry, cut the paper into 3-inch squares and roll each piece into a tight tube. When you light a tube, it will smoulder but will not burst into flame. The only drawback to touch-paper is that it produces a very acrid odor.

At first the smoke will swirl about in uneven eddies. Just wave your hand in the box or blow through the opening in the lid of the box to even out the smoke.

Finishing touches. The inside surfaces of the reticle plate and the hatch door should be covered with clean white paper to provide good target areas.

Except for these target areas, all interior parts of the smoke box and the lens box must be painted flat black to absorb as much light as possible. Use velvet or velveteen cloth on the rear of the smoke box, as mentioned earlier.

The exterior surfaces of the equipment can be painted any color you wish. A medium grey makes a handsome piece.

Using the smoke box. Now you are ready to begin experimenting. Round up as many optical elements as you can and just start lining them up at random to see how they bend the light rays. You will become familiar with the operation of the smoke box, and learn some fascinating things about lenses, prisms, etc.

Browse around a novelty store and you will find all sorts of lenses such as glass reading lenses—both double-convex and cylindrical types—and small plastic magnifiers that are cheap and quite handy for experimentation.

Some firms sell lens kits containing assortments of slightly chipped but wholly usable lenses. One kit contains such varied items as plano-convex, double-convex, double-concave, meniscus-negative, meniscus-positive and other types. Most of the lenses are quite small in physical size, but are fine for experimental purposes. Of course, you can also buy individual lenses of just about any size and description you want.

You can have a lot of fun making your own optical elements. A pill vial filled with water will serve as a cylindrical lens. You can shape prisms from block plastic or mold them from liquid embedding and casting plastic which is available at hobby and craft shops. After cutting or molding the prisms, polish to a very smooth surface, and wax to eliminate any remaining surface cloudiness. Such improvised optical elements do not compare in quality with the commercially sold glass items, but they are good for preliminary experimentation. When you know exactly what type of lens or prism works best in whatever you are putting together, you can order the real thing.

There are a number of highly practical booklets on how to build such optical devices as telescopes, microscopes, magnifiers, projectors, binoculars, and spectroscopes. Check your library for helpful publications. J.H.

WHERE TO FIND IT

The optical bench shown here consists of a rigid meter stick, two metal supports (one with a reticle, the other with a first-surface mirror) and four fully adjustable metal lens holders. It is available from Edmund Scientific Co., Barrington, N. J. 08007. Write to them for information.

Lens kits and a number of highly practical booklets on how to build such optical devices as telescopes, microscopes, magnifiers, projectors, binoculars and spectroscopes are also available from Edmund Scientific Co.

How to Mold Plastic Prints

You can use this technique for a variety of projects. The only equipment it requires is an easily made press

Vein patterns in leaves can be molded precisely, used in decorative displays, study or in exhibits at science fairs.

PRINT-MOLDING IS a craft technique that will enable you to make color slides for projection without the use of camera or film, make educational three-dimensional plastic replicas of such objects as coins and leaves, or create unique plastic panels that are ideal for decorating craft items such as boxes, book ends and lamps.

The products created by this print-molding technique are basically of two varieties. In some cases the original subject, for example a drawing or a printed picture, is transformed and permanently bonded to the plastic. In other cases the plastic merely captures a highly detailed imprint of a three-dimensional solid object, such as a coin.

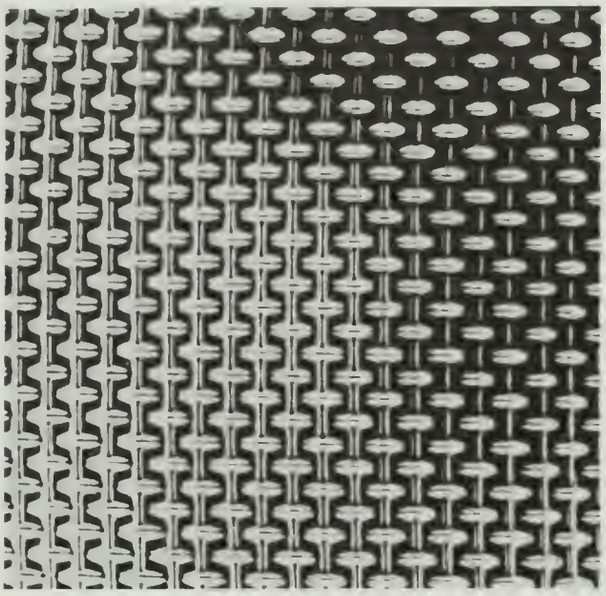
Heat and press. The secret of success lies in proper heating of the plastic, and the application of sufficient pressure to effect bonding, or the imprinting of a three-dimensional pattern. No elaborate or costly equipment is needed, and the plastic raw material is quite inexpensive.

The best raw material is one-sixteenth inch thick colorless acrylic plastic sheet that can be obtained from plastic retailers located in larger towns and cities. For sources, check the yellow pages. One square foot of plastic is enough for 36 experiments.

Cute the plastic sheet into two inch squares so that they will fit into an ordinary slide projector. The cutting can be done by scoring the plastic several times by drawing the tip of a sharp knife along a straightedge. But here's the trick: turn the knife tip upside down so that the point scratches rather than cuts the plastic. Snap the plastic apart along the scratch mark to get a clean break.

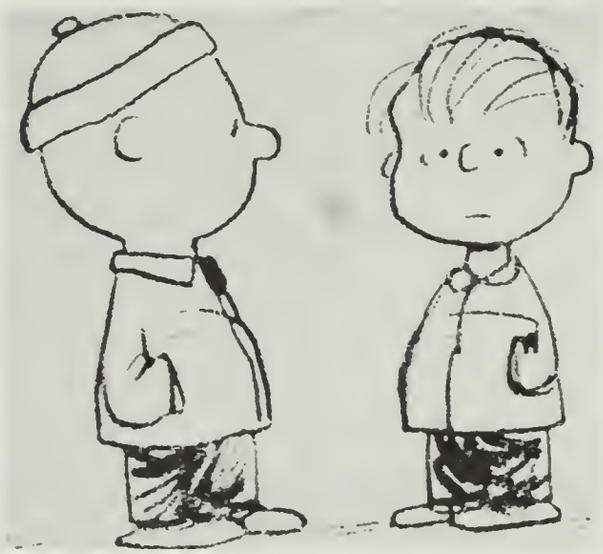
Use any convenient source of heat to soften the plastic. The kitchen range or an oven heated to about 400 degrees will do. However, a small hot plate is most convenient. Do not apply directly to a flame because the plastic will burn.

You will need two metal platens, about four inches square, between which to press the plastic sheet and the object to be bonded or imprinted. These platens must be very smooth, or the surface of the plastic will reproduce every scratch or irregularity



Example of texture which can be pressed into plastic. In this case, metal screen was used to create ripple effect.

Postage stamps can be affixed permanently to plastic, as is shown here, for an attractive way to display collector's items.



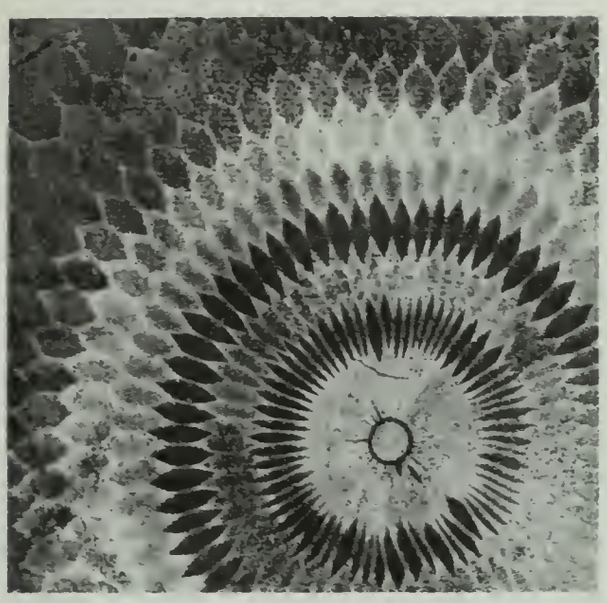
This is an ink transfer from a magazine illustration. It can be done in color or black and white and then projected.

on the platens and produce an inferior final product. The platens can be cut from a small chrome-plated ferrotype tin solid for photographic use. If a ferrotype tin is not readily available, use any reasonably smooth sheet metal at least ⅛-inch thick and make the surface smooth by folding a piece of household aluminum foil over it. Make sure that the shiny side of the foil is exposed, and that all wrinkles are carefully smoothed out. Such make-shift platens work surprisingly well.

Your main problem will be to find or build a suitable press. An ordinary shop vise can be used for initial tests, but it is not very convenient because of the difficulty of inserting the heated plastic and platen sandwich. A far more efficient press can be made from scrap lumber and a piece of pipe as shown in the illustrations. This press is fast acting and provides plenty of pressure. If you construct such a press, make certain that the moving jaw applies the pressure as even as possible. This is important.

Laboratory tongs are ideal for handling the hot platens. However large tweezers or kitchen tongs will also serve.

Experiment first by imprinting such objects as coins. Place a sheet of plastic on one of the platens and heat until it begins to soften. The softening is usually first evidenced by a slight upward curling of the corners of the sheet. When the plastic appears "rubbery," carefully turn it over with



Full color ink transfer from a magazine. It can be projected as a transparency, used in light show or for decoration.

Impressions of coins, such as this one, show remarkable detail when projected on wall for display or study purposes.

a pair of tweezers and heat a little longer. Place the coin on the plastic while the second side is being heated.

When the top surface of the plastic can be "dented" by a light touch of the tweezer tips, the plastic is just soft enough for pressing. *Avoid overheating!* Use no more heat than is necessary, and only long enough to soften the plastic to its "dent" condition. If the plastic begins to pop and crackle, it has been overheated; small gas bubbles that are forming will mar the final product.

As soon as the plastic is soft, place the second platen on the coin and quickly transfer the entire sandwich to the press. Bear down firmly on the press handle for about fifteen seconds. Pressure is more easily applied if the press is placed on the floor rather than on a table.

Remove the pressed sandwich from the press, or allow it to cool where it is. The coin will stick to the plastic while it is still warm, but will pop off easily when cool, leaving a highly detailed impression of the coin.

The "slide" is now ready for projection. You will be astonished when you see the fine detail that has been captured by the plastic. You may also note that the projected image has a rather unique—almost three-dimensional—effect when projected onto a screen.

Coin collectors can use such slides to point out minting details to large groups of people without risking loss of the original coins. Others can use the coin impressions for decorative purposes, just as they are, or after coloring them with plastic-adhering paints sold in hobby shops.

Enlarged photographic prints are easily made by projecting the images onto sensitized paper. For some reason, a slide projector produces better, more contrasty results than does a conventional photo enlarger.

Printed images of many kinds can be transferred and permanently bonded to the plastic. Suitable subjects include colored magazine illustrations, line drawings, postage stamps, etc. If you want projectable images, look for subjects that have been strongly printed on glazed paper. Try cutouts from magazine covers as a start.

The procedure is slightly different from

that used to make the coin impressions. Place the picture, face up, on one of the platens and cover with a sheet of plastic. Heat until the top surface of the plastic dents easily. Do not turn the plastic sheet over as before. Just add the second platen and quickly transfer to the press and apply strong pressure for about fifteen seconds. Let cool in the press.

Examine the results. The bonded picture should appear evenly glossy. If there are dull spots, indicating inadequate bonding, reheat and press again.

Perfect bonding is achieved much more easily if you employ this preliminary step. Dip the paper subject in ethylene dichloride plastic solvent (available from plastic supply stores) and carefully smooth it into the plastic sheet. Allow to dry for about 30 seconds, then proceed with the heating and pressing. *Caution!* Use the solvent where there is good ventilation.

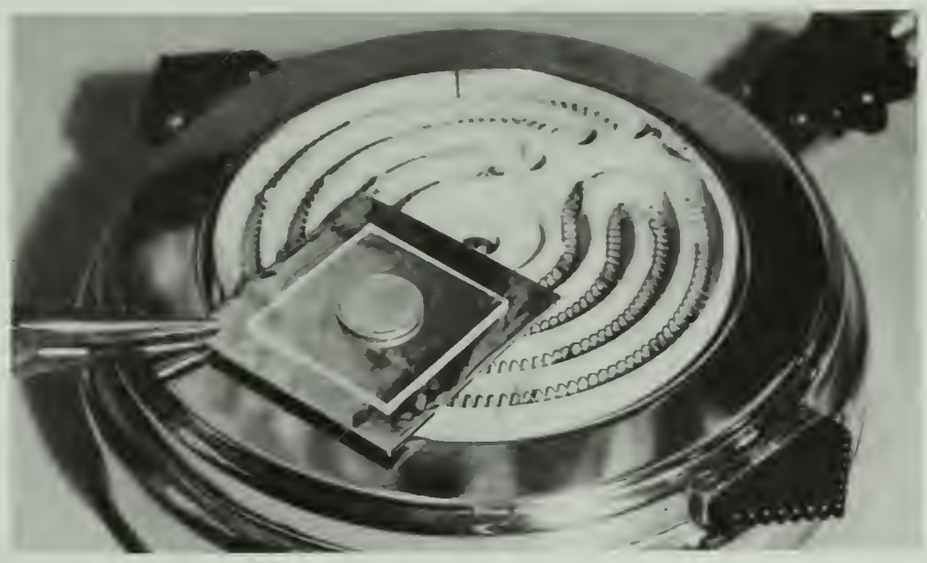
▲ *To cut thin plastic, score surface with blunt side of knife tip. Position score line over edge of a table and snap off.*

➤ *Metal platens must be very smooth. Fold and smooth aluminum foil over stiff sheet metal if polished metal is not available.*

The bonded picture can be used for many decorative purposes just as it is. However, if you are after a projectable transparency, the paper backing must be removed. First soak the slide in water for several minutes to completely wet the paper. Peel off as much of the paper as you can, then rub off the remainder using a wet finger or, in stubborn cases, a small hand brush. If the heating and pressing has been done properly, the pigment image will remain firmly bonded to the plastic.

When you project the slide, you will see the half-tone dots inherent in the printing process. So don't expect the projected image to look quite like an ordinary color slide. Nonetheless, the results are remarkably good and quite adequate for many purposes. Such subjects as magazine clippings and postage stamps make good projection slides. However, certain types of novelty stamps (such as those showing natural history subjects) contain a heavy, white pigment that blocks light transmission.

How can such print transfers be used? Electronics hobbyists can bond numbers cut from calendars, or words taken from magazine pages, and use these as labels on instrument panels, pilot lights and dials.



➤ *To make three-dimensional impressions of objects such as a coin, place object on top of plastic, heat and press.*

➤ *To transfer printed images to plastic, place the original specimen under sheet of plastic during heating and pressing.*

Photographers can make interesting title slides by transferring pen and ink drawings, made on smooth bond paper, to plastic slides. And for fun, try making a few slides that show favorite cartoon characters large as life when projected.

Incidentally, do not attempt to bond actual photographs to the plastic. It won't work.

An endless variety of decorative pieces can be made by pressing with such odds and ends of junk as wire window screening, perforated sheet metal, clock springs, gears. All such objects are handled in the same manner as the coins.

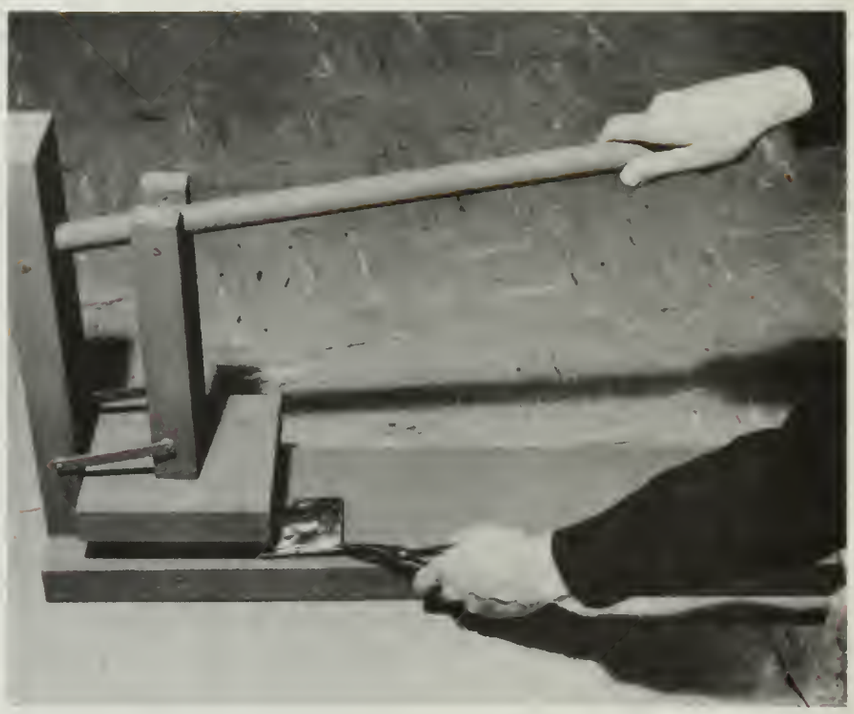
When you shop for plastic sheet, ask the shopkeeper to give you some scrap colored acrylic plastic. Break these into granules, file into powder, or make thin shavings using a carpenter's plane or a razor blade. Dribble the fragments onto the lower platen and cover with a clear plastic slide, then heat and press so that the colored pieces are fused into the sheet. Such mosaics are useful in many decorative applications.

Photography hobbyists can use the print-transfer method to make excellent unbreakable ground-glass for experimental purposes. Simply bond a piece of plain bond paper to the plastic, then remove the paper

by soaking and scrubbing. The plastic will then have an "etched" surface that is ideal for use as a focusing screen.

The application of this print-molding technique seem virtually endless. Some of the most unlikely subjects produce the most interesting results. For example, try imprinting the pattern of a small leaf onto plastic. In this case use the print-transfer technique (single heating method). When the leaf is removed from the plastic sheet, a remarkably detailed imprint of the leaf structure—even the smallest veins will remain. Such slides are excellent for educational purposes. Color the leaf patterns with plastic paints if you want some truly novel decorative pieces. J.H.

See also: PLASTICS, FABRICATING.



This simple press will make the pressing operation much easier. Build it from scraps of metal and wood. To operate, lift handle, place the plastic and metal sandwich between the base and block, press down firmly on the handle.